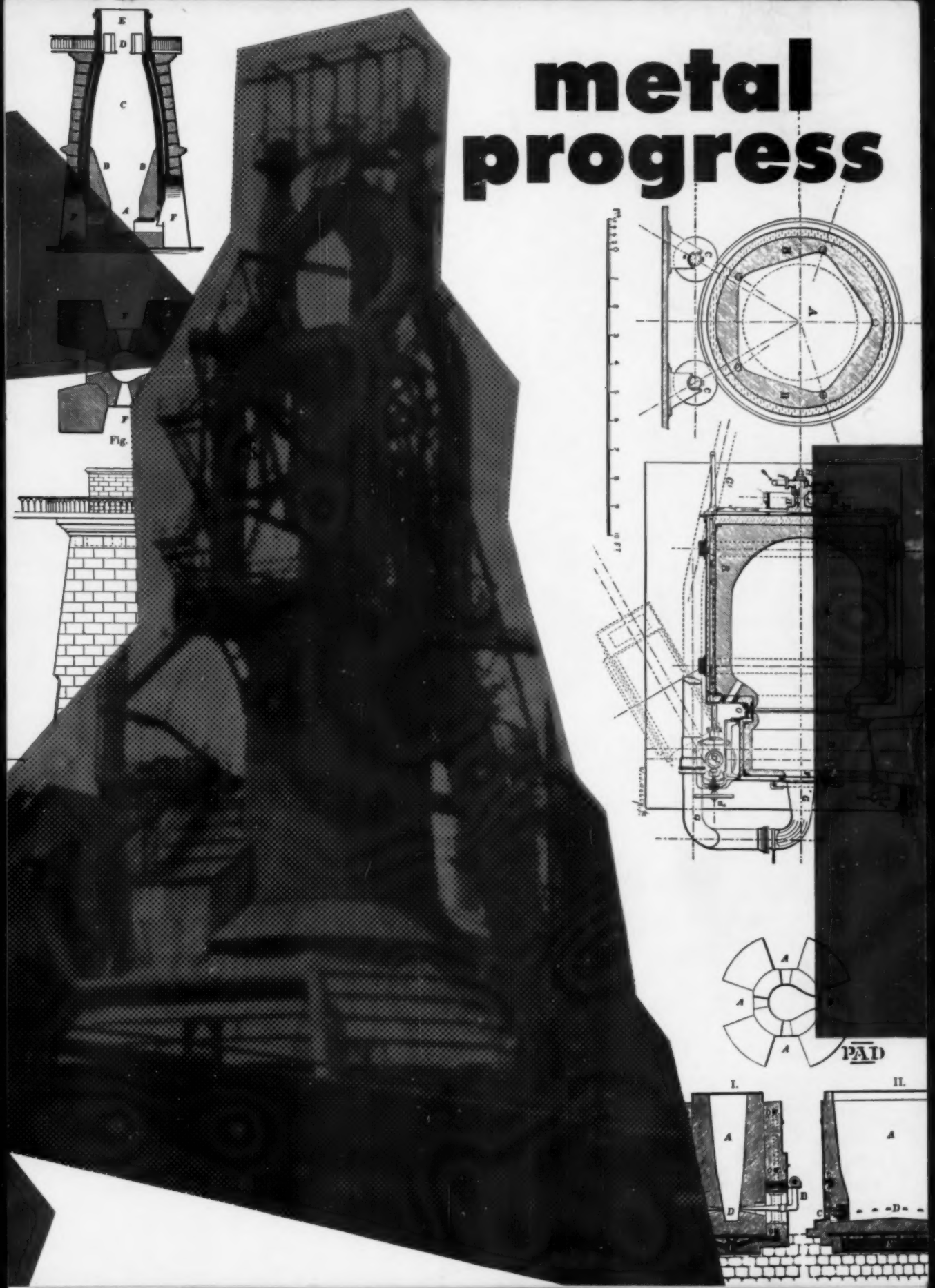
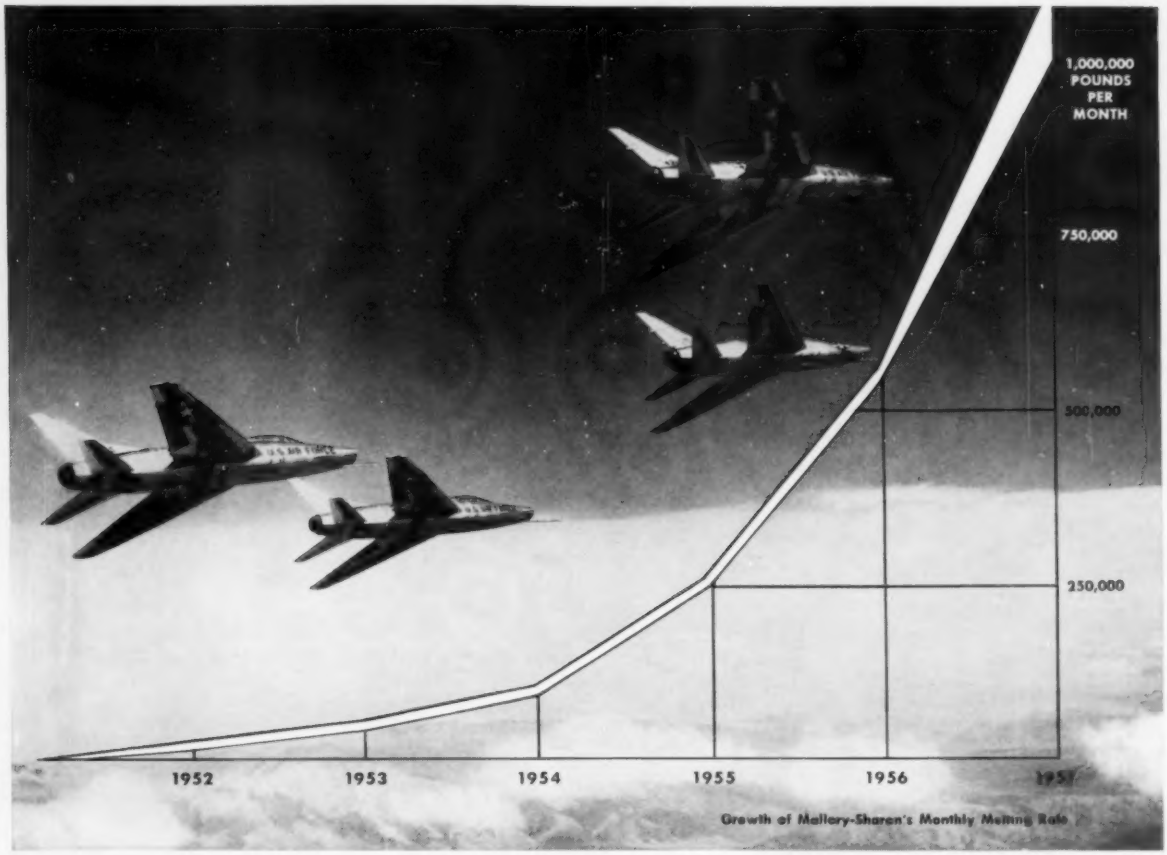
metal progress



Progress with **TITANIUM**



TITANIUM MOVES UP

Mallory-Sharon nears 1,000,000 pound-per-month capacity, dramatically improves quality, introduces new alloys

• Titanium continues to be a wonder metal in its growth.

This year Mallory-Sharon, a leader in titanium mill products, will produce more than the entire titanium industry in 1955. A major plant expansion now nearing completion will boost Mallory-Sharon's melting capacity to one million pounds per month.

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Metal Progress

Volume 71, No. 4

April . . . 1957

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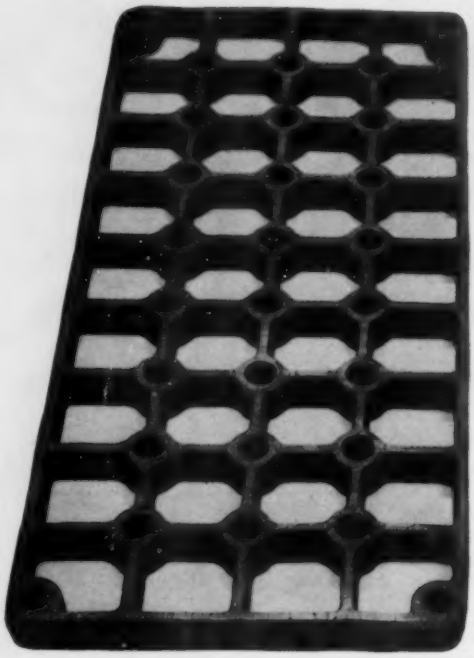
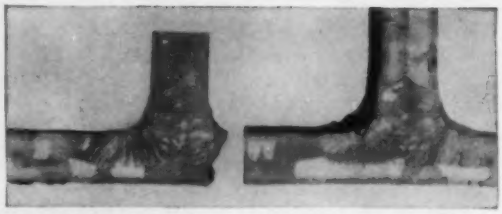
THE TALE OF TWO TRAYS





THERMALLOY TRAY—hot acid etch made after removal from service. Note that through proper chilling and foundry practice, most cracks are superficial.

COMPETITIVE TRAY—hot acid etch after failure shows severe shrinkage and cracking. This tray was in service *less than half* as long as the Thermalloy tray.

THERMALLOY* QUENCH TRAY
GIVES TWICE THE SERVICE LIFE

At a major automotive plant, two sets of quench trays were recently ordered for carburizing shafts at 1650 F. Both were of standard design. One set was cast by Electro-Alloys of Thermalloy heat-resistant alloy—the other was a competitive make.

The illustrations above clearly show the condition of the two test trays . . . after the Thermalloy trays had been in service *more than twice as long* as the competitive make. Use of chills at critical points and proper foundry technique in the Thermalloy trays accounted for their much longer service life . . . by eliminating the shrinkage evident in the competitive tray. This test, made by the customer, clearly proved the added quality and strength achieved through the use of chills.

Whatever *your* heat-treat problem, it pays to make use of Electro-Alloys casting know-how—plus the outstanding physical properties of Thermalloy high-heat-resistant alloys.

For further technical information on Thermalloy Heat-Treat Trays, write for Bulletin T-227 . . . Electro-Alloys Division, 8034 Taylor Street, Elyria, Ohio.

*Reg. U. S. Pat. Off.

American Brake Shoe Company **ELECTRO-ALLOYS DIVISION** Elyria, Ohio

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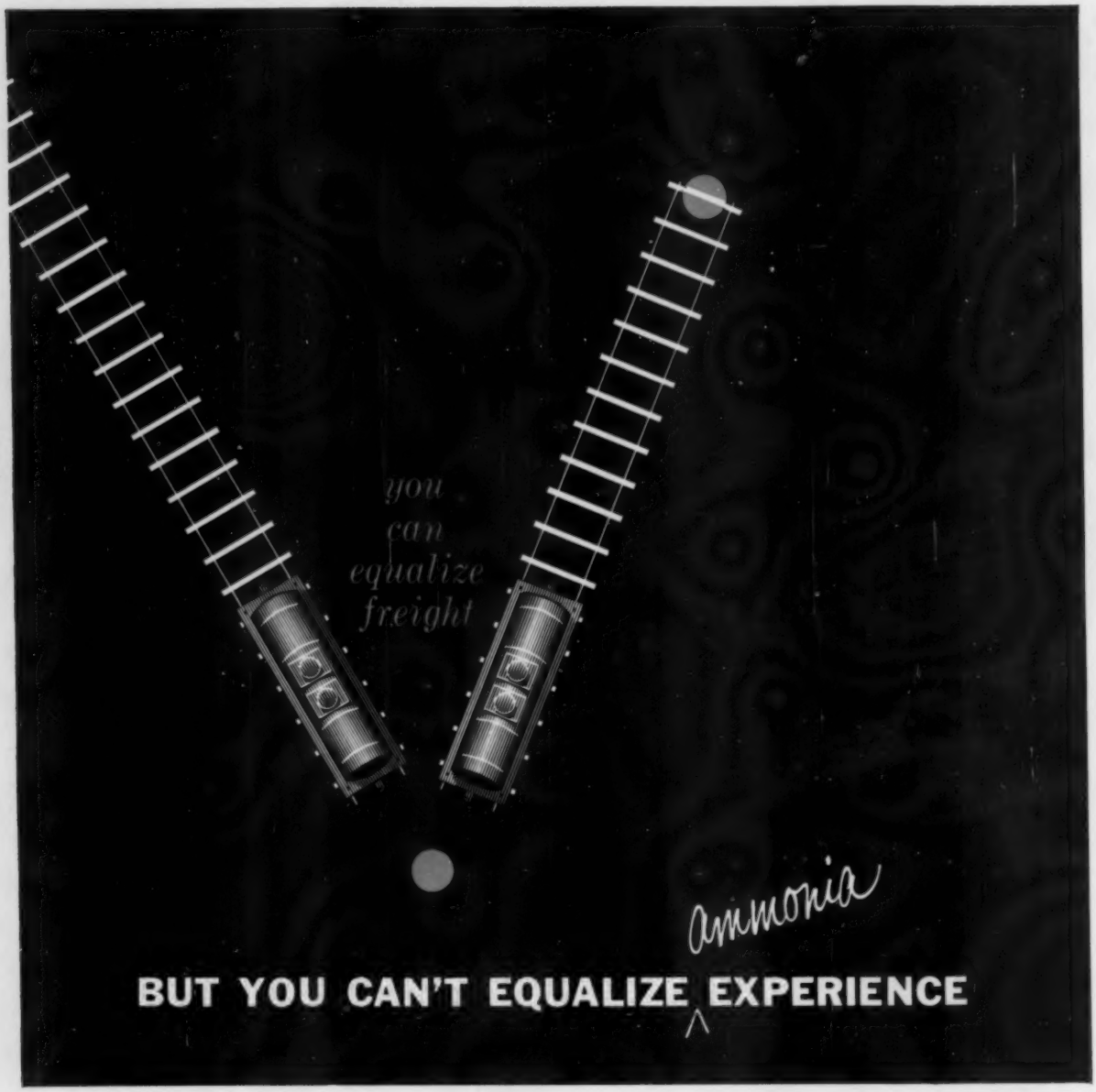

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As I was saying...

– and have stated many times before, the success of the A.S.M. is largely the result of the hard, conscientious and faithful work of the members of the executive committees of the chapters. As we travel about and visit with units of the A.S.M., we are deeply and clearly impressed with the tremendous amount of time, effort and thought the chapter officers and committeemen pour into the local activities. And these efforts are not selfishly inclined only to the chapter's success – these capable men are always conscious of the best interests of the individual members and the national organization as a whole.

The most outstanding proof of this wide interest is remarkably portrayed by the actions of some of the larger chapters of the Society in fostering the "fissionization" of new chapters in nearby communities, even though it may threaten a loss (in some instances, of more than a hundred members) to the mother-chapter.

Some interesting instances of this paternal (or maternal) instinct are: New York aiding the formation of the Long Island Chapter, Chicago the Chicago-Western, the Carolinas Chapter assisting in establishing the Old South and Columbia units, Detroit aiding Jackson, Philadelphia generating offspring in both Wilmington and Trenton, Pittsburgh financing a one-year tryout for the members at Beaver Valley, the Los Angeles Chapter helping San Fernando Valley and working on San Gabriel Valley, and the latest – Golden Gate – helping to create the Santa Clara Valley Chapter.

In every instance the assiting chapter has within a year recouped the lost members, and the new chapter has had a steady and healthy growth. This unselfish action demonstrates better than anything else the high ideals of service held by the executive committees of the A.S.M. chapters.

With President Don I visited both the San Fernando Valley and the Santa Clara Valley Chapters and found them to be worthy offspring of most estimable progenitors.

It is a well-known fact that as a chapter increases in membership the interests of the members become more diversified. Consequently it is more difficult to satisfy, or even cover, the major interests of the members with the limited number of technical meetings (usually six) held in a chapter season. Some chapters have divided their programs into two types – regular meetings and seminars. The second monthly meeting (the seminar) has been having splendid success. It is more technical in its subject matter and has an appeal not only to those interested in the subject but to many other members who are anxious for self-improvement.

As I stated in the opening lines of this epistle, the chapter executive committees are the men who are doing things that place the A.S.M. at the forefront of metals engineering. The chapters have served the metal industry in a most capable manner, studied the needs of the territory each serves, and have so conducted the affairs of the chapter that each community as well as the world appreciates the fact that

"The A.S.M. is worthy of your trust".

And it's all because of you, the members of the A.S.M.'s chapter executive committees. So, our hats are off to you!

Cordially yours,

Bill

W. H. Eisenman, *Secretary*
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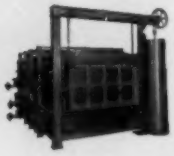
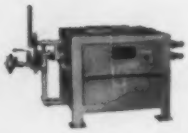


large oven

small oven

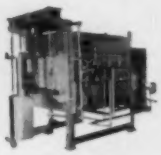
laboratory

circular pot

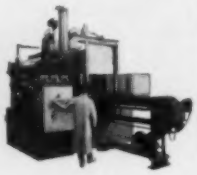


rectangular pot

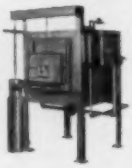
forge



balco® atmosphere



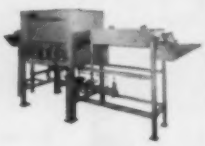
allcase® atmosphere



horizontal muffle

vertical muffle

brazing



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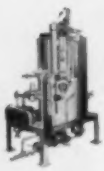
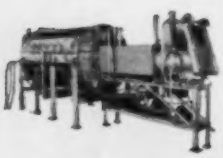


MRX® atmosphere generator

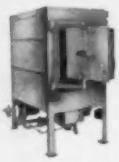
MDX® atmosphere generator

MAX® atmosphere generator

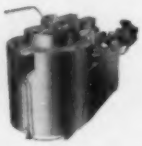


stainless steel

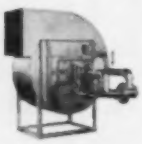
rivet heater



horizontal convection



vertical convection



direct air heaters

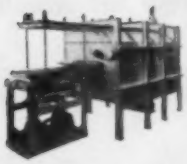
C E

tilting metal melting

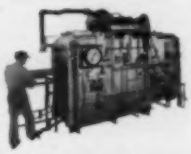
stationary metal melting

soft metal melting

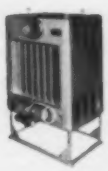
aluminum melting-holding



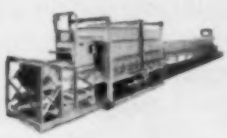
continuous snap hearth



continuous link belt



indirect air heaters



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Tom Corcoran, Lindberg Plant Superintendent, and V. O. Chase, Gulf Sales Engineer, inspect extension sockets coming out of Super-Quench, after going through a continuous atmosphere controlled furnace.

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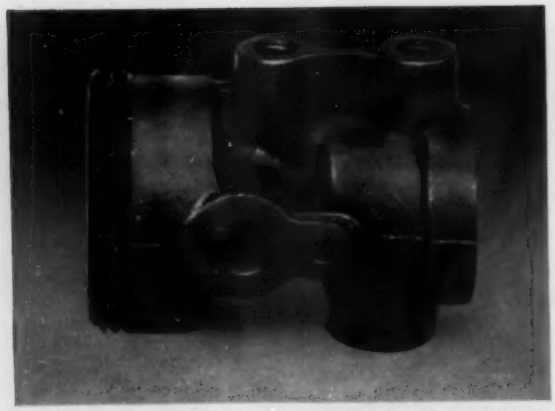
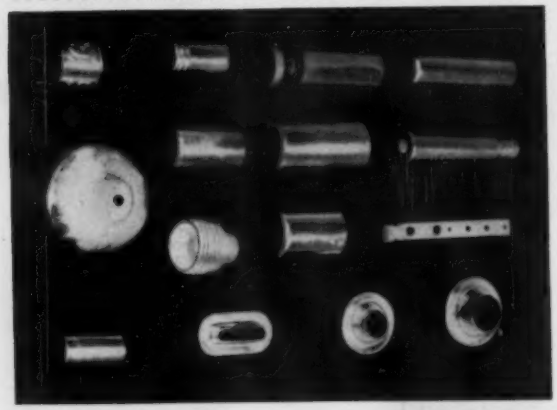


Replaces Cadmium Plating . . . These grey cast iron valve bodies are used in the pneumatically operated sanders that deliver sand for improved traction under the wheels of trains, trolleys and trucks. Their manufacturer had a double-barreled problem . . . porosity in the castings was causing excessive rejects . . . expensive cadmium plating was necessary to prevent corrosion in service.

Steam treating has solved both problems in one operation. Rejects due to porosity have been eliminated, and many valves previously rejected have been salvaged. Cadmium plating has been eliminated entirely because exhaustive salt spray tests showed the steam-treated finish had a higher resistance to corrosion.

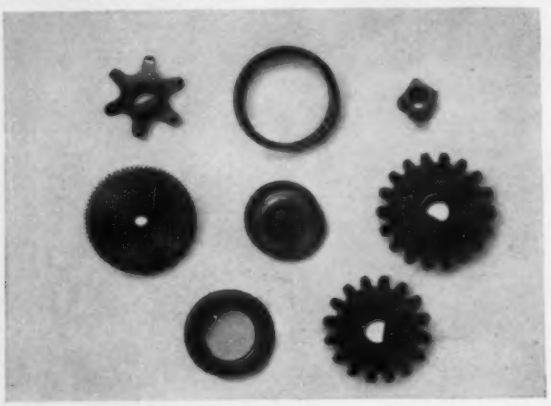


Cuts Expensive Pickling Costs . . . Non-ferrous lipstick tubes and other cosmetic containers made by a large Canadian manufacturer must be annealed before finishing operations can be performed. Scale was a problem. If left on, it ruined tools and dies . . . removing it meant expensive, messy pickling.

The solution was found when sample parts were annealed by the steam Homo* method. When this method was adopted as an integral part of the production line, pickling was eliminated. Subsequent figures from the cost-accounting department showed that eliminating this operation reduced annealing cost by 53 percent.

Puts "Extra-Life" in Cutting Tools . . . A machinery manufacturer faced a tough problem when specifications called for milling a 0.250 inch wide key-way slot into a piece of 4140 cold-rolled bar stock which was heat treated to a hardness of Rc 34 to 38. In addition, tolerances were tight . . . ±0.001 inch . . . with sides perfectly square.

The first high-speed steel tools used produced only four cuts and could not be resharpened because of the close tolerance. Hard-chroming the same tools improved cutter life to about 11 pieces per tool. Carbide tools held up for from 11 to 14 pieces. The next move was steam treating experimental batches of tools in an L&N furnace. The first batch averaged 100 parts per cutter, a second batch, 60 to 70 and a third lot, 100 to 125.



Raises "psi" of Powdered Iron Parts . . . Although many parts made of powdered iron function satisfactorily in the as-sintered condition, there are others where an increase in hardness and compressive strength is an advantage.

This is particularly true of such parts as the steam-treated gears, cams, etc., shown at left, where additional strength is needed on critical bearing surfaces. The shock-absorber piston in the center, for instance, presented a real problem . . . how to meet psi specifications for the thin-section flange around the outer edge. Steam treating proved a cheap, practical solution. Tests showed compressive strength of the flange increased from 1200 to 1400 psi. In addition, the parts, when oil dipped, had a pleasing uniform, blue-black color and high corrosion resistance.

Is steam treating an "unknown-quantity" to you?

■ If you work with metal . . . ferrous or non-ferrous . . . and haven't considered steam atmosphere heat treating for your product, you may find you've overlooked an unsuspected source of surprisingly substantial savings.

For in scores of plants it's becoming an outstanding cost-cutter on parts made of high speed steel, powdered iron, carbon steel, grey iron, brass aluminum and beryllium copper. And its advantages are almost as numerous as the materials being steam treated.

On high speed cutting tools, for instance, it keeps tools sharp longer. On powdered iron, compressive strength and hardness increase appreciably. On carbon steel it gives a uniform, attractive, blue-black finish. On grey iron it seals against porosity and gives a high degree of corrosion resistance. On non-ferrous parts it produces scale-free work ready for bright dip or often for use "as-is."

Here and on the opposite page are just four examples to illustrate our point. If you want others . . . or details on any of these . . . or want us to help investigate possible savings you can make, just phone your nearest L&N office or write us at 4927 Stenton Ave., Phila. 44, Pa. Catalog TD2-620(1) tells all about it, too; we'll be glad to send you a copy.

LEEDS NORTHRUP
instruments *automatic controls • furnaces*

If you would like to investigate the effect of steam treating, we will be glad to steam treat sample parts from your own plant for you.

Speed for
aluminum extrusion . . .

Westinghouse

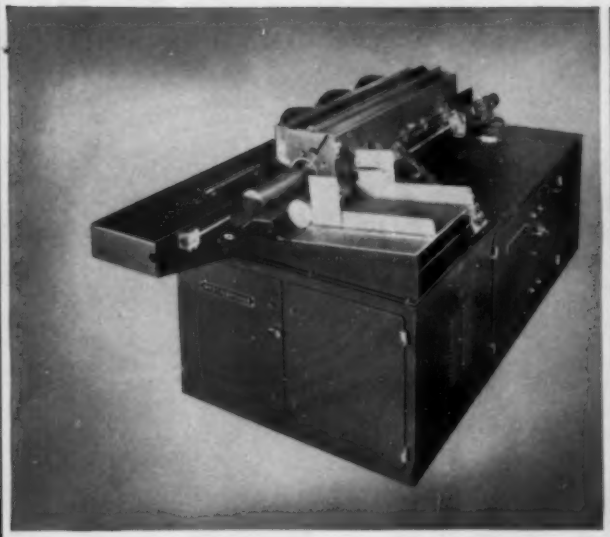
1. Greater efficiency in aluminum billet extrusion results from the speed and adaptability of Westinghouse induction heating.

C. P. Bernhardt
Engineering Manager,
Induction Heating Dept.

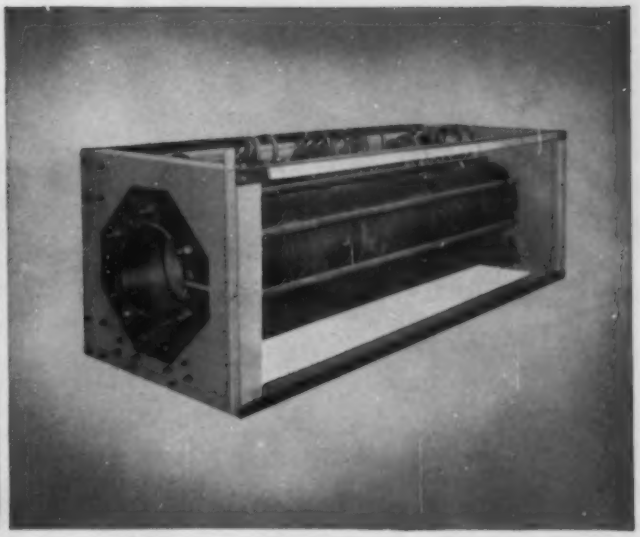
EXAMPLE: "Five thousand pounds an hour of 6-inch aluminum billets", reports Carl Bernhardt, "are heated to 1,000°F for heavy extrusion press operation." In supplying induction heating for this customer, Westinghouse saved 37% of the floor space needed for conventional furnace operation. Most important, high operating efficiency results from these five advantages in speed and flexibility:

• Short, 3-minute, start-up time. Stand-by heat losses are low.

induction heats billets on the run



2. Heating 6- or 8-inch billets to 1,000°F, this Westinghouse induction unit delivers up to 5,000 lbs of billets an hour.



3. Westinghouse coil design and engineering assures uniform heating from billet core to surface.

- Up to 80% cut in maintenance time and costs.
- Longer die life due to uniform billet heating... accurate, repetitive temperature control.
- Cooler, more productive working conditions.
- Pushbutton, automatic cycling of billet heating and handling directly to the extrusion press pickup.

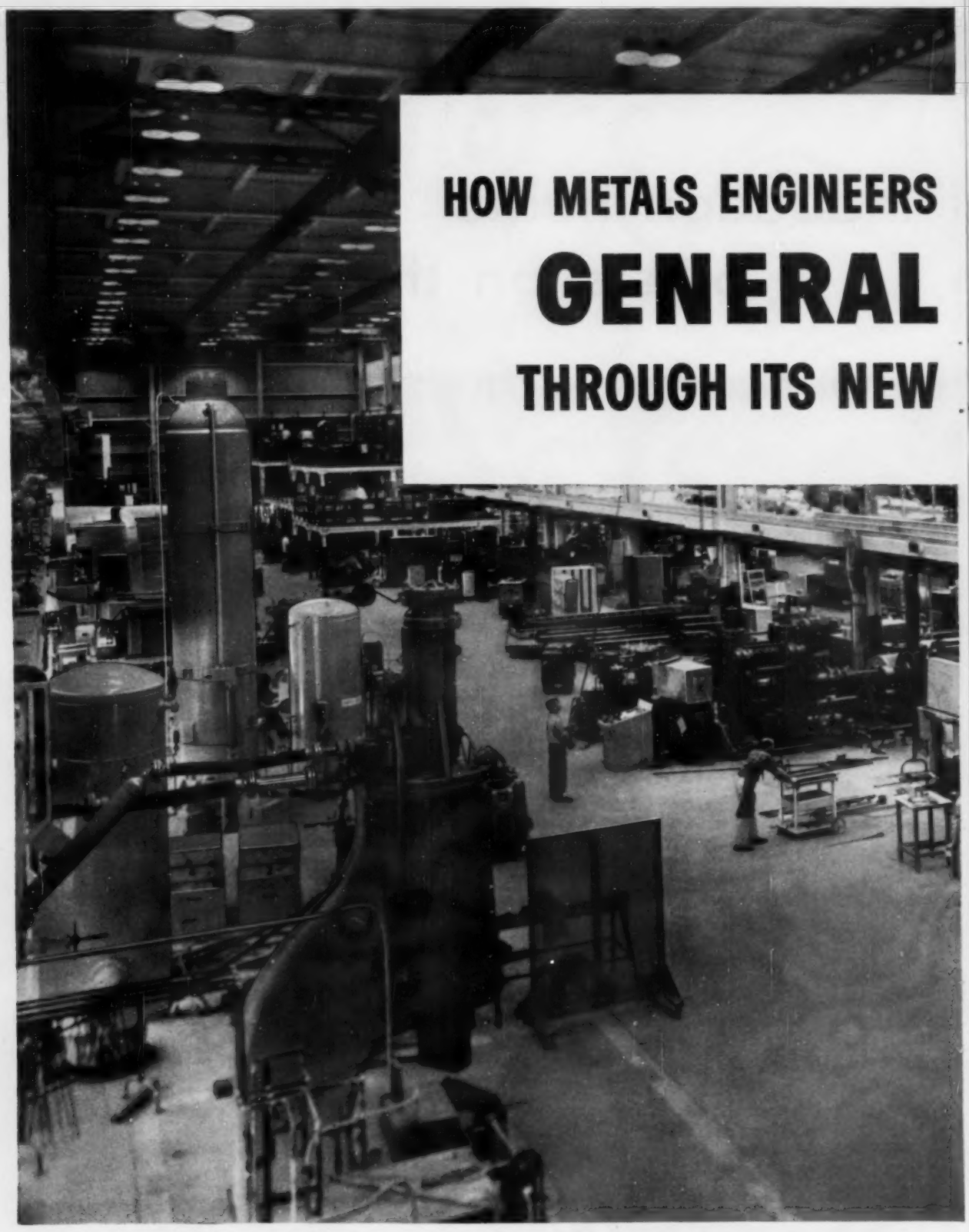
For problem solving, call on Westinghouse technical leadership in induction heating research, design and engineering. You can be sure of complete service, too, through installation field engineering and follow-up. See your local Westinghouse industrial heating sales engineer or write, Westinghouse Electric Corporation, Induction Heating Dept., 2519 Wilkens Ave., Baltimore 3, Md. J-10450

The Westinghouse Heat-Treating Family

GAS • ELECTRIC • INDUCTION

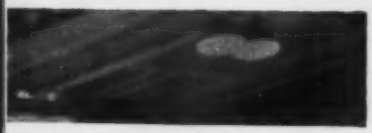
YOU CAN BE SURE... IF IT'S

Westinghouse



HOW METALS ENGINEERS GENERAL THROUGH ITS NEW

Laboratory with factory-size equipment—that's the new $5,000,000 G-E metals and ceramics laboratory in Schenectady. From here will come many of the products manufactured by the Metallurgical Products Department of General Electric Company, 11167 E. 8 Mile Street, Detroit 32, Michigan.



BENEFIT FROM THE RESOURCES OF
ELECTRIC
METALLURGICAL PRODUCTS DEPARTMENT

Solutions to your most pressing problems — plus developments ahead of industry trends — are now being worked out in our laboratories

Because designers needed a metal harder and more wear-resistant than steel, General Electric brought out Carboloy® cemented carbides. Because designers needed a more powerful magnetic material, General Electric developed improved types of Alnico permanent magnets. Because designers needed better high-temperature metals, General Electric created new vacuum-melted alloys.

These, and many other vital products for metals engineers, are the result of General Electric's tremendous resources of technological know-how and skilled manpower in the field of metallurgy. They are created in G-E laboratories . . . and produced for industry by the new Metallurgical Products Department.

This Department is the successor to the Carboloy Department, which was originally organized to manufacture carbides. It now produces such widely divergent metallurgical products as hevimet, thermistors, and Thyrite® varistors . . . in addition to chrome and tungsten carbides, and permanent magnets.

The very range of its products indicates how the resources of General Electric are being put to work solving the metals engineer's most pressing problems through modern metallurgy.

Perhaps more important, G-E resources like the new Research Laboratory in Schenectady, and the manufacturing facilities of the Metallurgical Products Department, are now combining their talents to produce *ahead* of the trends and needs of industry.

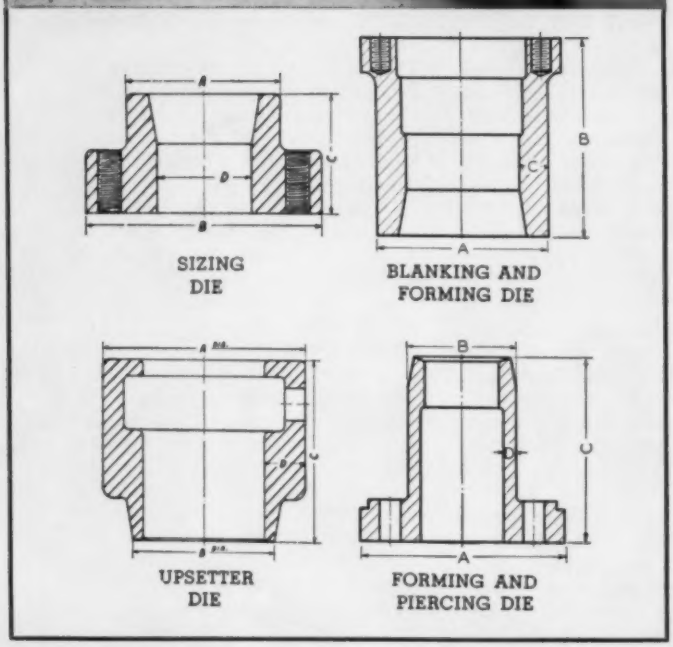
In the Metalworking Industry, for example, this combination of G-E resources has already made one such contribution: Carboloy Cemented Oxide — a new kind of cutting tool material with so great a potential for super high-speed machining, that new machine tools must be designed to take advantage of all it offers.

Developments like these are essential to industrial progress . . . and they are typical of the parade of products metals engineers can expect from the G-E Metallurgical Products Department.

Progress Is Our Most Important Product

GENERAL ELECTRIC

SPEED PRODUCTION, CUT WASTE WHEN MAKING RING-SHAPED TOOL STEEL PARTS



New Graph-Mo® Hollow-Bar eliminates drilling, machines 30% faster

IF you make ring-shaped tool steel parts, you'll find that you can speed production, cut waste, and save steel by using Graph-Mo® Hollow-Bar. That's because Graph-Mo Hollow-Bar comes with the hole already in it. There's no drilling. You start with finish boring.

And with Graph-Mo Hollow-Bar you get the combination of proved advantages that have made Graph-Mo one of the most popular tool steels: excellent machinability, exceptional wearability, unsurpassed stability.

Actual tests prove that Graph-Mo machines 30% faster than other tool steels. That's because Graph-Mo has free graphite in its structure. And this free graphite gives Graph-Mo less tendency to pick up, scuff, and gall.

Graph-Mo's amazing wear resistance stems from a combination of graphite and diamond-hard carbides. Reports from users indicate that Graph-Mo outwears other tool steels on an average of three to one.

Graph-Mo also is the most stable tool steel ever made. A master plug gage made from this steel showed less than ten millionths of an inch dimensional change after 12 years in use. And Graph-Mo responds uniformly to heat treatment, too.

Makers of ring-shaped tool steel parts may obtain Graph-Mo Hollow-Bar in sizes from 4 to 16 inches O.D. with various wall thicknesses.

To learn more about Graph-Mo Hollow-Bar, and its application to your problems, write The Timken Roller Bearing Company, Steel and Tube Division, Canton 6, Ohio. Cable address: "TIMROSCO".

TIMKEN *Fine Alloy* **STEEL**

TRADE-MARK REG. U. S. PAT. OFF.

SPECIALISTS IN FINE ALLOY STEELS, GRAPHITIC TOOL STEELS AND SEAMLESS STEEL TUBING

APRIL, 1957 Vol. 4 No. 1

NATIONAL CARBON COMPANY'S

CARBON AND GRAPHITE NEWS

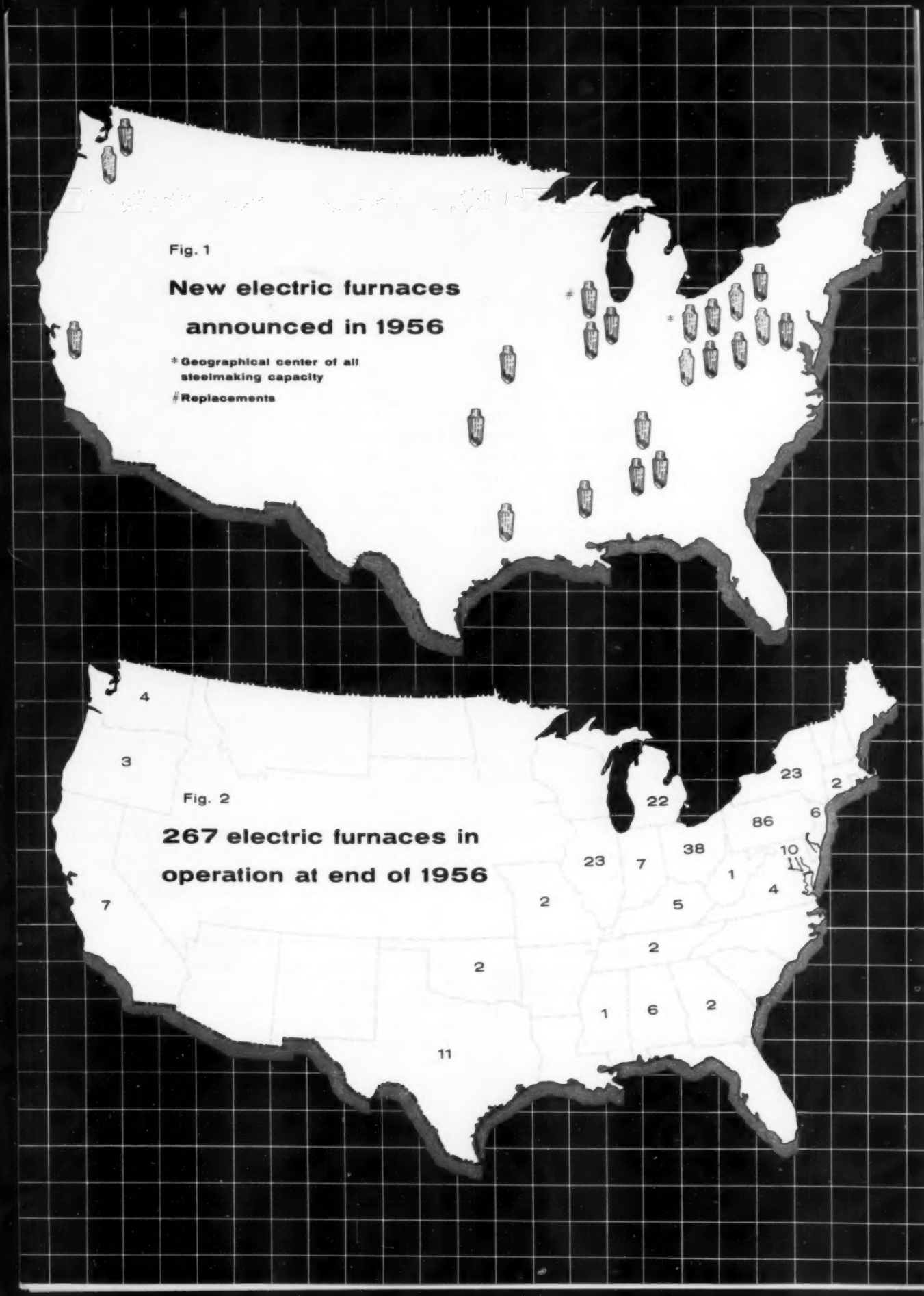


Fig. 1
New electric furnaces announced in 1956
*Geographical center of all steelmaking capacity
#Replacements
Fig. 2
267 electric furnaces in operation at end of 1956
4
3
7
2
2
11
1
6
2
2
5
23
7
38
1
4
10
86
6
22
23
2

Electrics make their move in '56

Plans for the installation of a record 19 new electric furnaces — with a total capacity of more than 2.5 million tons — were announced by steelmakers during 1956. In addition, replacement of existing furnaces with larger units will add another 372,000 tons, boosting the new electric furnace capacity disclosed during the year over the 2.8 million ton mark. At the end of 1956, there were 267 electric furnaces in operation, with a record installed capacity of 11,501,700 tons. This new high, together with unprecedented expansion plans, made 1956 a really big year for electrics.

Geographic scattering of these new units, which represent more than 25 percent of new steelmaking capacity, is illustrated in *Fig. 1*. The fact that a majority of the new electric furnaces are to be in locations remote from the geographic center of the country's steelmaking capacity speaks well for the inherent characteristics of the electric furnace that make it possible to take advantage of local scrap, power, and market conditions in planning new facilities. *Fig. 2* shows the distribution of the 267 electric furnaces in operation at the end of 1956.

This tremendous surge in electric furnace activity is characteristic of the fabulous growth of this versatile steelmaking tool since the first heat was poured just over 50 years ago. By 1915, total electric furnace steel approximated 80,000 tons, which could be produced today in just one medium-sized furnace. From 1935 to 1955 electric furnace capacity increased 925 percent, as contrasted to a comparable growth of 61 percent for the open hearth.

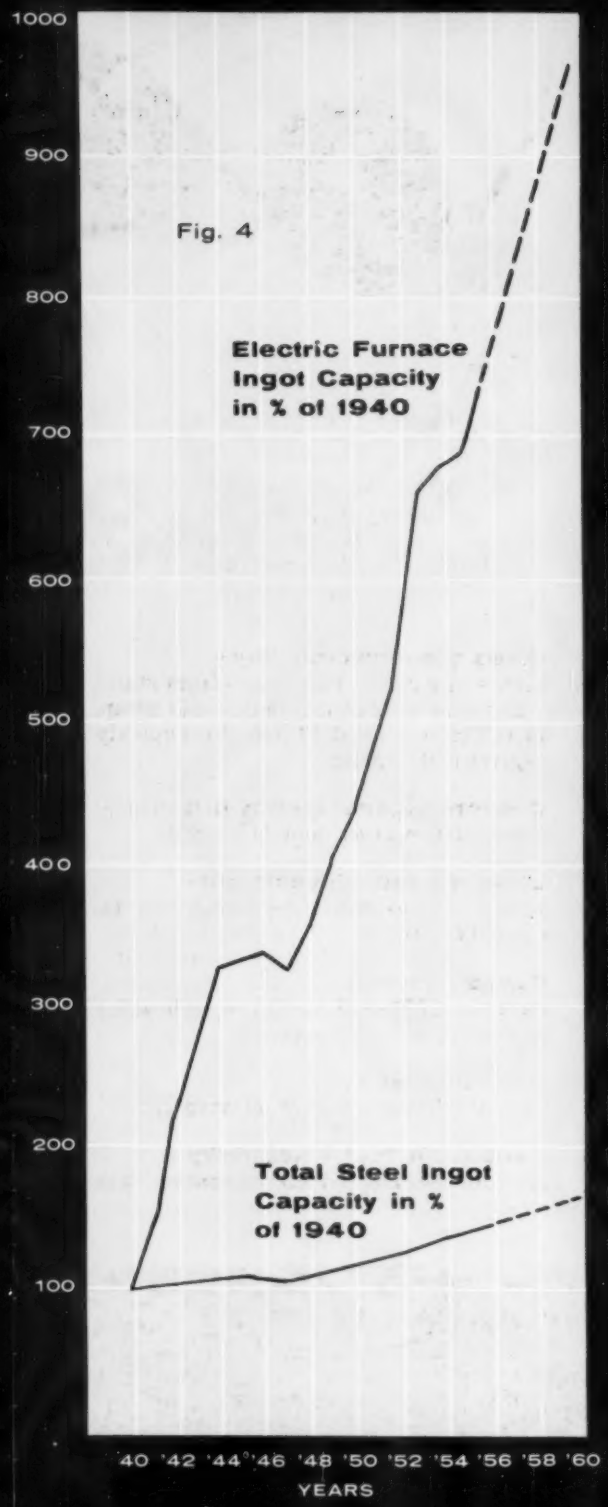
Plain Carbon Steel Sets Pace

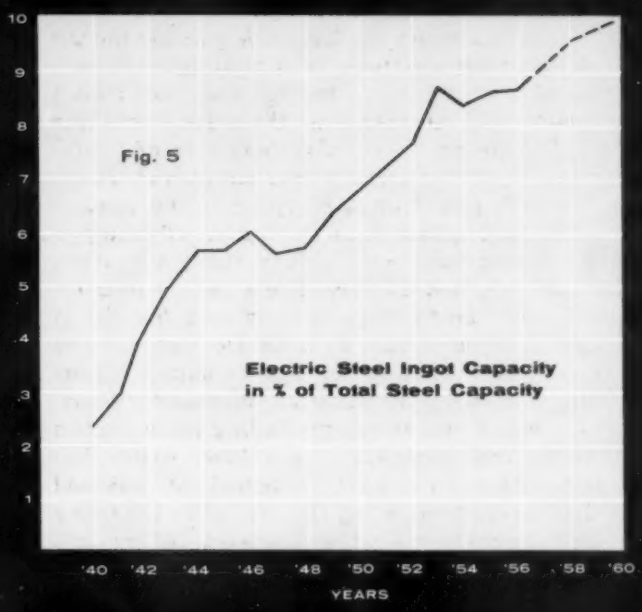
By 1940, electric furnace steel capacity had risen to 1,500,000 tons per year, or about 2.3 percent of total steel capacity. Most of these electrics were confined to the production of alloy steels. Following World War II, the industry was faced with the problem of utilizing electric furnace capacity that had been producing armor plate and other specialty steels required for the war effort. It was at this time that serious consideration was first given to the electric furnace as a producer of plain carbon steel. As shown in *Fig. 3*, the curve of the percentage of carbon steel ingots made in the electric furnace took a sharp swing upward, and has been rising ever since. By 1947, electric furnace production of plain carbon steel caught up with and passed electric furnace alloy steel production. Each year since then the greatest gains have been in plain carbon steel. Some industry observers estimate that by 1975 approximately 30 percent of total carbon steel ingots will be produced by electrics.

As the electric furnace is becoming an increasingly important factor in the production of plain carbon steel, and continues to play a leading role in the production of alloy and stainless steels, it naturally follows that electrics are assuming a more predominant position in the steelmaking industry as a whole. The curves of *Fig. 4* compare electric furnace ingot capacity and total steel ingot capacity in terms of 1940 levels, and illustrate the much more rapid growth of electrics as compared to the total capacity. Although the industry as a whole has followed the characteristic growth curve, electric furnace capacity has obviously passed through both a development and surge phase, and is now evidencing the characteristics of normal, healthy growth. The growth of electric steel capacity as a percentage of total steel capacity is shown graphically in *Fig. 5*.

Technology Fosters Expansion

Along with the increase in the size of the electric furnace industry have come logical technological developments that have played an important part in making this growth possible. The removable roof, higher capacity transformers, and improved regulation systems have been important contributions that have made possible larger and larger units. The original hand-charged three-ton electric furnace has grown into today's top-charged 200-ton giant, with even larger units contemplated. It is likely, some experts predict, that the larger furnaces of the future might well utilize six electrodes in an elliptical shell. Because of the electric furnace's flexibility, in shops where demand charges on electric power are a major consideration, a mixture of large and medium units can be used in order


1000
900
800
700
600
500
400
300
200
100
Fig. 4
Electric Furnace Ingot Capacity in % of 1940
Total Steel Ingot Capacity in % of 1940
'40 '42 '44 '46 '48 '50 '52 '54 '56 '58 '60
YEARS


10
9
8
7
6
5
4
3
2
1
Fig. 5
Electric Steel Ingot Capacity in % of Total Steel Capacity
'40 '42 '44 '46 '48 '50 '52 '54 '56 '58 '60
YEARS

5
4
3
2
1
Fig. 3
% of Carbon Steel Ingots Made in Electric Furnaces
WORLD WAR II
'40 '42 '44 '46 '48 '50 '52 '54 '56
YEARS

to maintain a high load factor.

Improved regulation has made possible the use of higher powered furnaces, permitting quick melting of the light scrap that has been used almost exclusively in electrics since the end of World War II. The greater energy-absorbing area of lighter scrap allows the use of higher power, and removable roofs permit quick charging, so the developments go together in increasing the efficiency of the electric furnace to the point that plain carbon steel production is competitive with open hearths.

In addition to supplementing open hearths in fully integrated mills as desirable consumers of revert scrap, electric furnaces are almost universally accepted to be the economic answer to non-integrated operations producing plain carbon steels. Some steelmakers have chosen to use electrics and scrap to level out periods of peak and slack production, rather than resort to the heavy capital investment in blast furnaces. Others have found the flexibility offered by electrics to be the answer to their diversification problems, and still others are thinking of duplexing with oxygen converters. No matter how the future of steelmaking is approached, the electric furnace is in the picture.

Charging Developments Affect Future

One of the few deterrents to the unlimited growth of the electric furnace in the United States is the scrap situation. During recent months, domestic scrap prices have actually exceeded the price of pig iron, and consequently increasing attention is being given to hot metal charging of electric furnaces. The desiliconization of hot metal and the production of electric furnace pig iron are developments to be closely watched. A number of means for the direct hydrogen reduction of ore have been developed and publicized, and are not to be discounted.

The evolution of a good hot-metal practice for the electric furnace, and the development of a source of directly-reduced iron (other than blast furnace iron) for charging will open up an almost unlimited future for electric steel. With fuel costs for open hearths estimated up some 25 percent by 1975 (in terms of 1956 dollars) and electric power costs being reduced by increasing the efficiency of generation, the favorable open hearth economics of recent years will disappear. It is significant that electric furnace melting has been employed by the six most recent entrants into the steelmaking industry.

Perhaps every year can't be the big year 1956 was, but authorities visualize a growth in the electric furnace production of carbon steel of approximately 1,000,000 tons a year for the next 20 years, with alloys adding another 6,000,000 tons total. Although new steel-producing processes will also find their places, the electric furnace's flexibility, geographic independence, temperature control, deoxidation ability, start-up and shut-down ease, minimum space and labor requirements, and relatively low capital investment indicate many more "big years" ahead.

Look Ahead—
Look Electric

Gives greatest flexibility—
Makes any steel—any time—from stainless to plain carbon. Handles cold scrap, metallics, hot metal. Starts, stops quickly—gives faster melts.

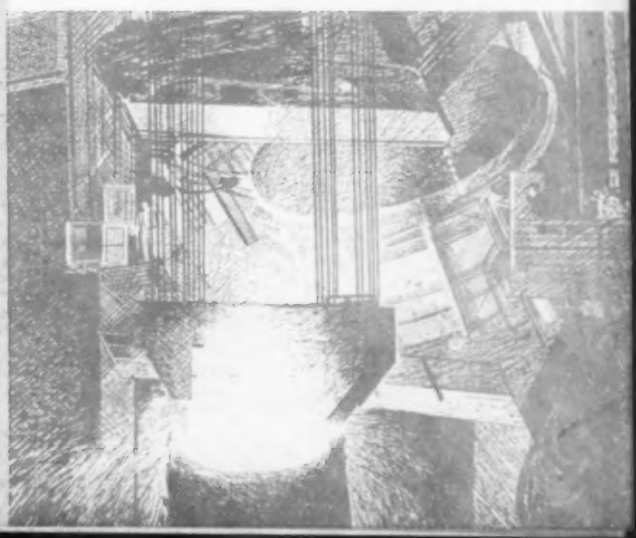
Delivers highest quality product—
Closer temperature control possible.

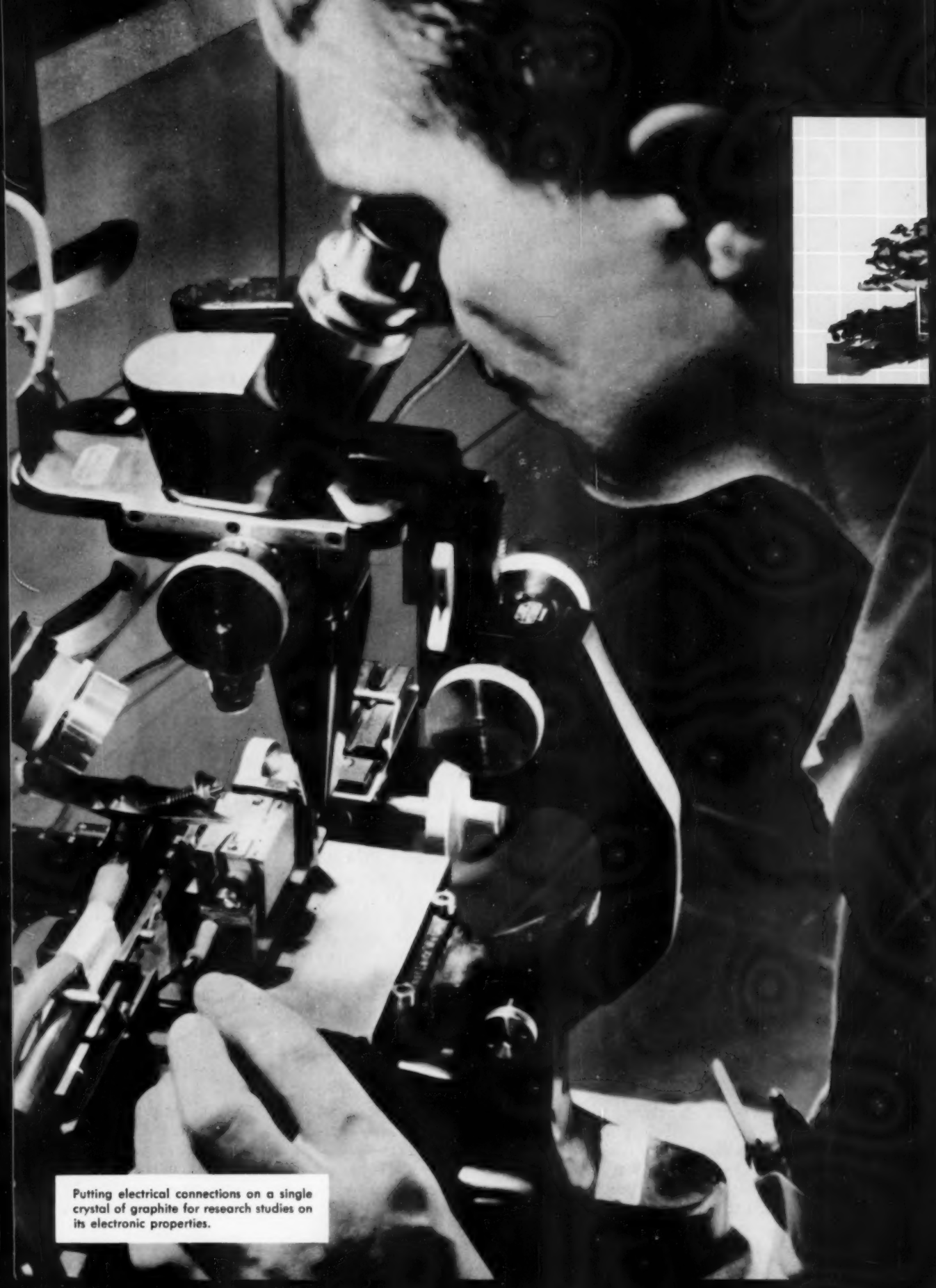
Lowers capital investment—
40% less than equivalent open-hearth capacity.

Saves space—
Savings of 25% and more vs. open hearths producing same tonnage.

Goes up fast—
Capital investment pays off sooner.

Uses clean fuel—electricity—
No combustion products to contaminate melt.





Putting electrical connections on a single crystal of graphite for research studies on its electronic properties.

Working at the outer boundaries of knowledge

RESEARCH AT NATIONAL CARBON'S NEW LABORATORIES, PARMA, OHIO

Albert Einstein once expressed the opinion that the trouble with theoretical physics was its frequent inability to provide quick solutions to urgent practical problems. Long recognizing the validity of this observation, National Carbon Company shuttles its immediate practical problems to its Product Development Laboratories; turns over theoretical and basic research to the highly specialized teams of scientists at its newly dedicated Research Laboratories at Parma, Ohio.

At this ultra-modern, multi-million dollar facility, research combat teams attack fundamental problems in four highly complex, strategic areas — carbon and graphite basic research, high temperature processes, solid state physics (and closely related chemical physics) and electrochemistry. These teams seek the basic concepts from which the answers can subsequently be fashioned to many practical questions on electric furnace electrodes, refractories, nuclear power plants and nuclear armament, high temperature lubricants, electro-winning of metals, the electrochemistry of new battery systems and many other areas of prime importance to industry.

Basic Carbon and Graphite Research

Carbon and graphite electrodes, carbon brick, carbon blast furnace and cupola linings, carbon brushes for motors and generators are all vital tools of the trade well known to the steel industry. To seek new and better forms of carbon for these and countless other existent and future applications is Parma's mission today. The task is formidable when one considers the roadblocks to research thrown up by the peculiarities of the element carbon itself. The traditional techniques for working with such materials as iron and steel or copper and brass are not applicable to carbon for here is a substance which can neither be melted nor cast in molds as can most metals and plastics.

It is not found in nature in usable sizes or shapes, so products of carbon must be manufactured — a process which involves making a suitable mix of finely ground particles and binding agent, molding or extruding the resultant mixture to desired size and shape and then carefully heat treating under precisely controlled conditions for unusually long time cycles.

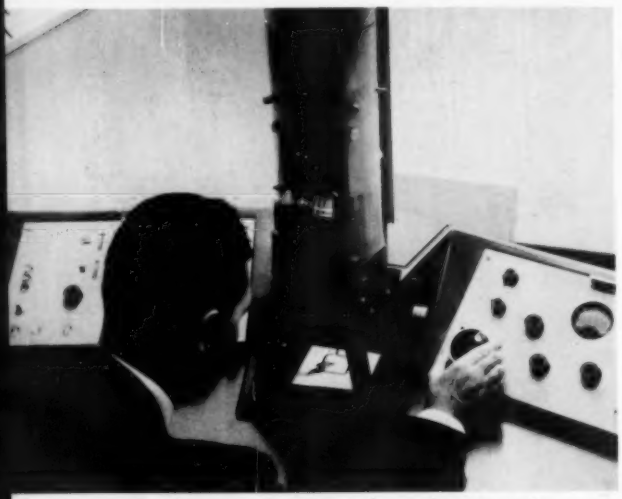
Single Crystals Yield Their Secrets

All carbon and graphite materials basically consist of clusters of many, many small graphite crystals. The great variation in electrical and thermal behavior between what appear to the eye to be similar carbon specimens is explained by the variations in sizes and physical relationships between the tiny graphite crystals within these several carbon specimens.

It is such variations which account for the wide range of thermal conductivities exhibited by various specimens of graphite. One lot can be manufactured with a thermal conductivity five times greater than copper's; another lot with an insulation value greater than that of ordinary building brick — a conductivity range factor of more than 1000 to 1!

In order better to study carbon's properties and, more importantly, to enable the tailor-making of a particular carbon with a predictable set of properties for a specified application, it is necessary to isolate and investigate single graphite crystals. Until recently, this has proven a most

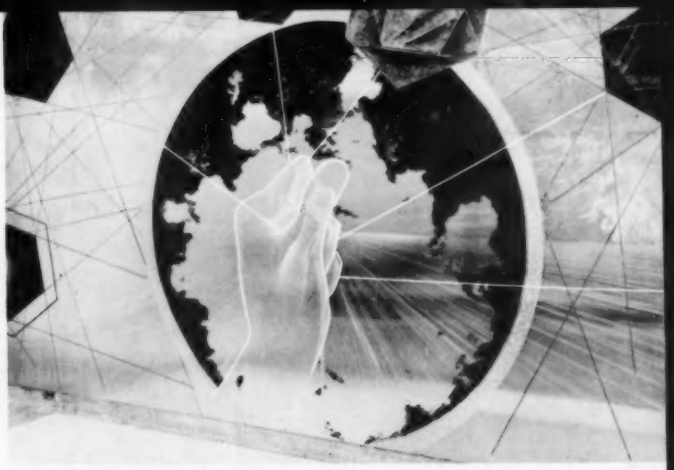
frustrating area to explore because impurities in the crystals defied eradication and thus distorted experimental data. But now National Carbon scientists have perfected new techniques for purification which remove chemical contaminants from the crystals and, at the same time, banish imperfections and weaknesses from the crystalline structure itself. Result: fused graphite crystals approaching the ideal for purity and structural perfection — a "break-through" of major significance along the roadway leading to fundamental quantitative data on graphite's behavior.



Electron microscope probes carbon's mysteries.

High Temperature Refractories

Another significant field of inquiry having great potential importance for industry is the Parma Laboratories' investigation of high temperature phenomena with emphasis on the synthesis of a new, broad class of super-hard materials to perform satisfactorily at temperatures over 4,000°F! Typical is titanium diboride, the hardest man-made material having no counterpart in nature. Successfully made at Parma by company-developed fusing methods, titanium diboride slices through fine knife steel easily, is suitable for cutting stainless, holds much promise for rocket motor nozzles and turbine blades. And there is titanium carbide, extremely hard and corrosion resistant. And cerium monosulphide destined for a major role in producing zirconium and titanium, metals vital to nuclear power plants and jet engines. These are but a few of the high temperature materials of tomorrow being perfected as a result of basic research in National Carbon Laboratories today.



Symbol of Modern Research—Emblazoned in Epoxy Resins and Stainless Steel . . . The Story of Man's Endless Groping for Knowledge. (From Impressive New Mural Executed by Buell Mullin for National Carbon Research Laboratories)

Beyond The Outer Boundaries Of Knowledge

Where does this elaborate, far-flung program lead? Perhaps the most revealing tip-off comes from observing the scientists involved, watching their restless zeal as they pursue the answers to questions which, until recent years, could not even have been asked. It soon becomes apparent that this huge research endeavor, despite its complexities, is directed toward a clearly perceivable goal — the extension of the frontiers of pure science, breaking through the outer boundaries of today's knowledge.

If you would like to know more about the important work being done at Parma, send for our free booklet "Research"—Just address: Advertising Department, National Carbon Company, 30 East 42nd Street, New York City 17, New York

The term "National" is a registered trade-mark of Union Carbide and Carbon Corporation

NATIONAL CARBON COMPANY

A Division of Union Carbide and Carbon Corporation
30 East 42nd Street, New York 17, N. Y.
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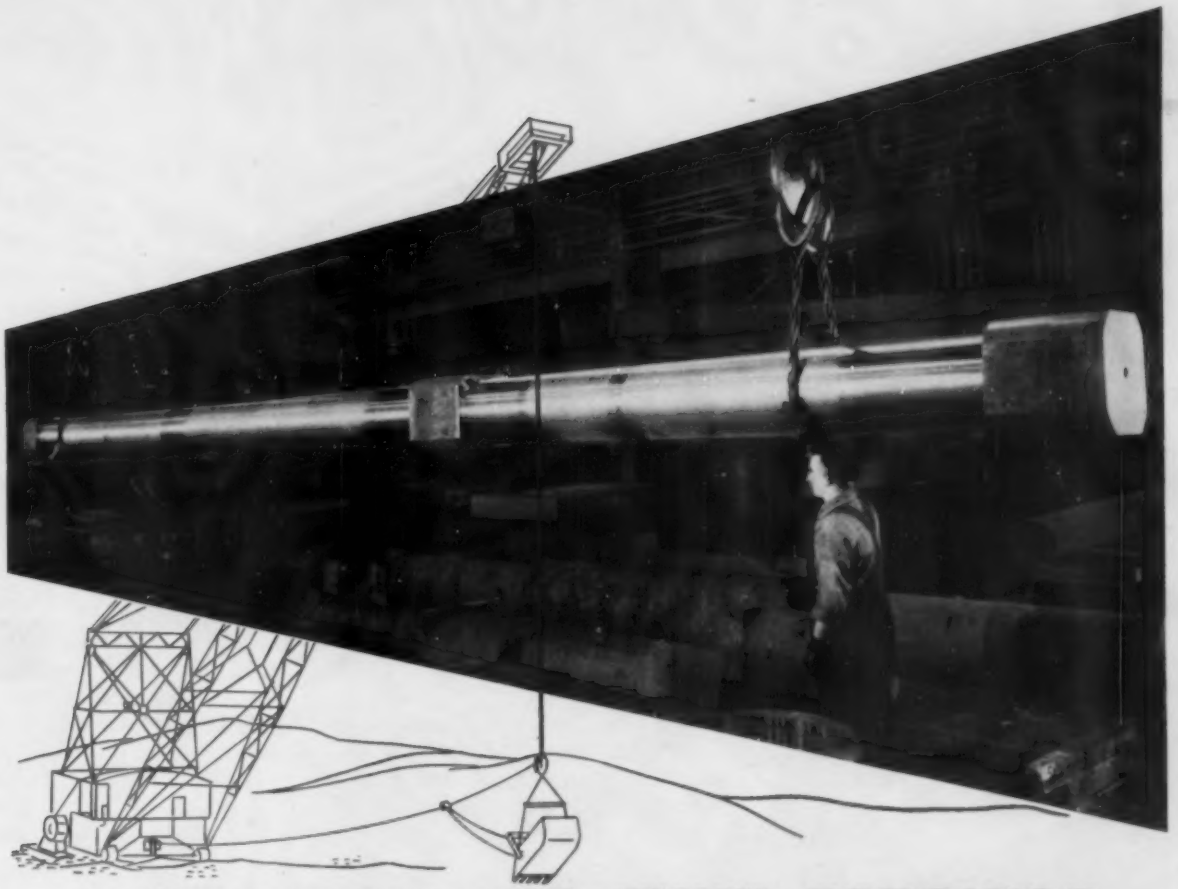

SAVE MONEY with FINKL FORGINGS

Manufacturers of earth moving equipment do!

• DIE BLOCKS • HOT WORK STEELS • FORGINGS • ELECTRIC FURNACE STEELS •

Walking draglines are ingenious, mobile monsters employed for digging and moving earth. Because of their size and applications, often in isolated areas, they must be dependable and steady in their operations. Only the best materials and workmanship will prevent costly downtime in the field.

Many of these machines employ Finkl forgings. The 48 foot "walker" shaft shown above transfers power from the engine to the walking mechanism of the dragline to move as much as 450 tons of equipment. Here the best materials and craftsmanship will prove the least expensive in the long run.

For over 78 years, Finkl has produced the best in cylinders, spindles, driveshafts, and special forgings both rough turned and finish machined. When you are considering forgings or die blocks, call your local Finkl representative.

A. Finkl & Sons Co.

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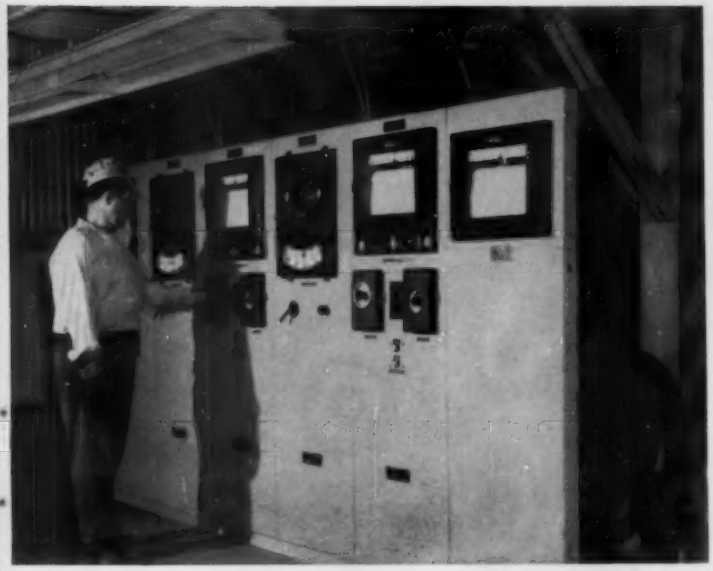
COLORADO SPRINGS · SAN FRANCISCO · SEATTLE · BIRMINGHAM · KANSAS CITY
Warehouses in: CHICAGO · BOSTON · LOS ANGELES

The floor charging machine at left is loading an ingot into a heating furnace. At right is the control panel with ***ElectroniK*** strip chart program controllers.

ElectroniK program controllers automatically regulate soaking and cooling furnaces. These furnaces are also equipped with Honeywell multiple burner ***Protectoglo*** flame safeguard systems. The control cabinet of one of these systems is shown at upper right.



These *ElectroniK* program controllers automatically regulate the heating furnace time-temperature program. The panel also contains two Brown indicating pressure controllers which regulate furnace draft.

Program your time-temperature cycles...

with *ElectroniK* controllers

A large eastern producer of specialty steels uses Honeywell *ElectroniK* program controllers for automatic control of heating and soaking furnaces. These controllers have the flexibility needed for the variety of work handled—stainless and heat-resisting steels, matched tool and die steels, high nickel alloy steels, and special purpose alloys.

In the press shop, where a hydraulic press reduces ingots for rolling, *ElectroniK* strip chart program controllers automatically regulate four heating furnaces and two soaking furnaces. These instruments are ideal for this type of operation because their control point settings, and heating, soaking and cooling rates are easily changed to meet the time-temperature requirements of various kinds of stock.

Where a process calls for *repetition* of a prescribed time-temperature pattern, *ElectroniK* circular chart cam program controllers are used to advantage. Once the program is cut on the plastic cam, it can be repeated over and over again with consistent accuracy.

For time-temperature program instrumentation matched to your own particular requirements, call your nearby Honeywell sales engineer. He's as near as your phone.

MINNEAPOLIS-HONEYWELL REGULATOR CO., *Industrial Division*, Wayne and Windrim Aves., Phila. 44, Pa.—in Canada, Toronto 17, Ont.

● **REFERENCE DATA:** Write for Catalog 1531, "*ElectroniK* Controllers."

H HONEYWELL

MINNEAPOLIS **Honeywell**

BROWN INSTRUMENTS

First in Controls

Does your **Cylindrical** *problem call for a* **Centrifugal** *solution?*

If your product plans call for hollow cylindrical parts, give some thought to these facts. Manufacturers who had never seriously considered cast parts before are discovering important advantages in Sandusky centrifugal castings.

They're getting exceptional resistance to heat, corrosion, abrasion and stress, through the use of special alloys cast centrifugally . . . in diameters from 7" to 54", and lengths to 33 feet depending on diameter . . . and specially machined to specifications.

How can our versatile staff and facilities help you? Tell us your product requirements. Let us explore your ideas. Perhaps we can help solve your cylindrical problems through the vast foundry experience, metallurgical research and machining skills our 46 years offer.

Your request will bring more information promptly . . . or, if you prefer, a personal call by one of our engineers. Sandusky Foundry and Machine Company—Sandusky, Ohio.

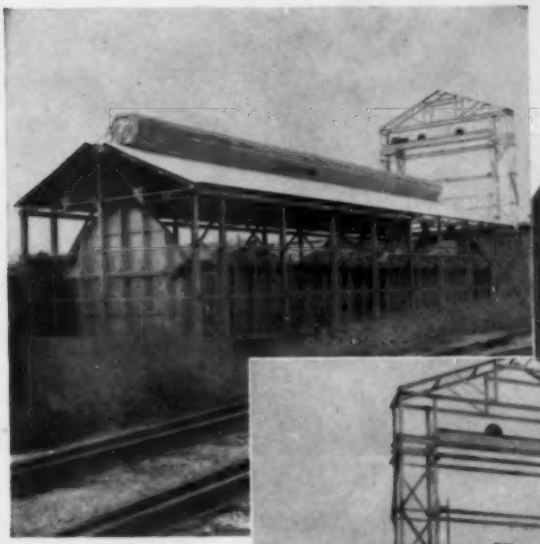
Sandusky centrifugal castings offer you 4 important advantages:

1. ***SUPERIOR STRENGTH***—through non-directional mechanical properties
2. ***BETTER QUALITY***—machined castings are porosity-free
3. ***UNIFORM SOUNDNESS***—harmul inclusions are forced out by spinning motion
4. ***JOB-READY FINISHED CASTINGS***—reach you machined exactly to your specifications . . . eliminating extra costs from rejects, down-time, loss of production, etc.

Sandusky Centrifugal Castings

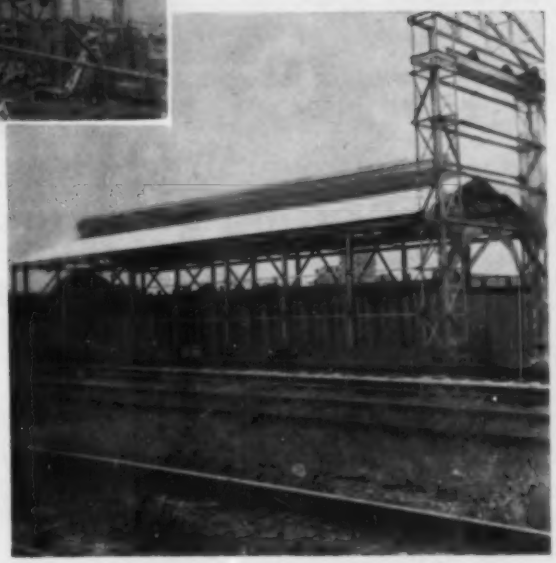
Stainless steels—plain carbon and low alloy steels—wide variety of copper base compositions

See Our Booth #1339 at the Design Show



You Say that you want it

KING SIZE?

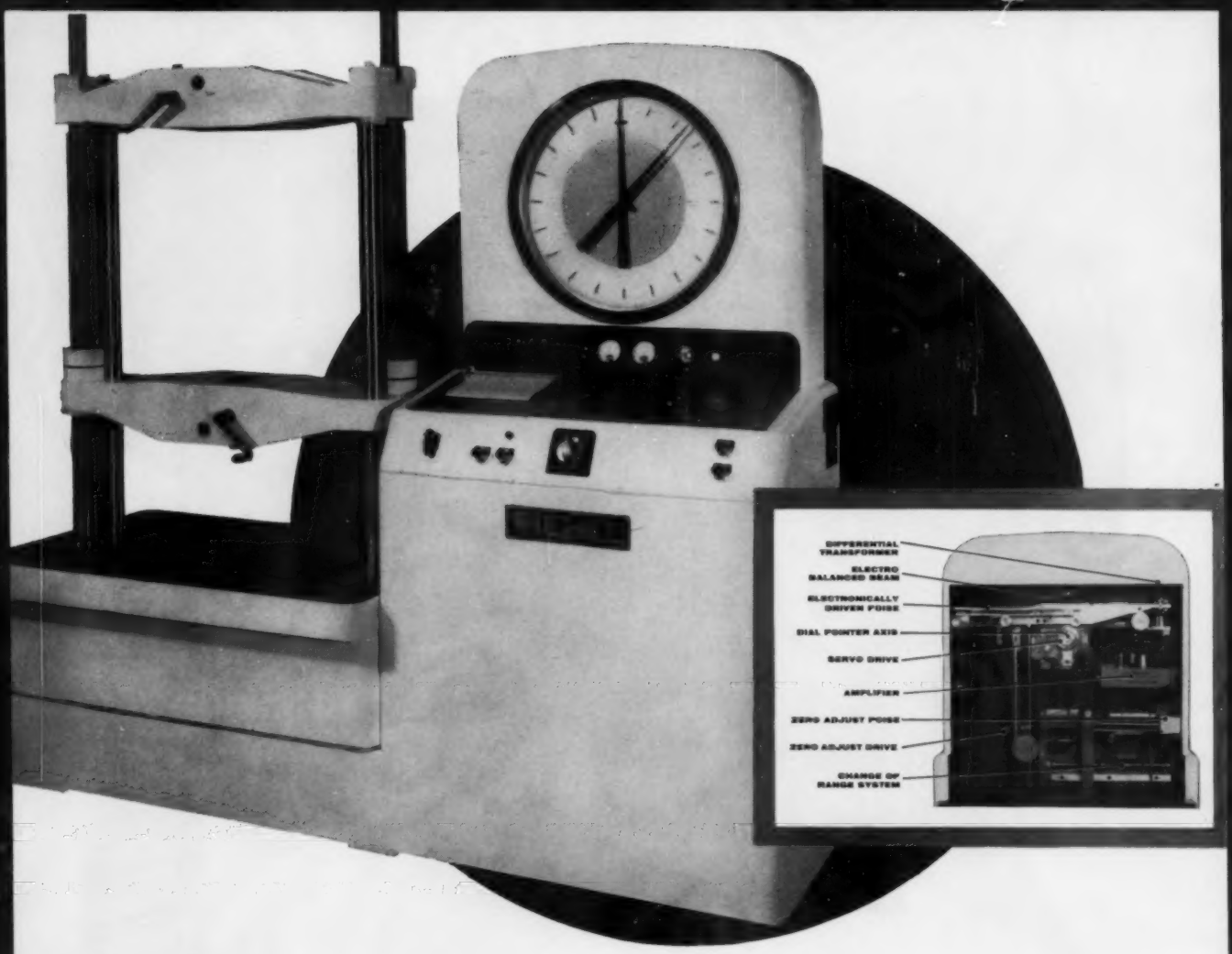


All right . . . look at this

This Car-type stress relieving furnace has been designed and built by F. & D. engineers for the J. B. Beaird Co., Inc. of Shreveport, La. This gas-fired unit will stress relieve pressure vessels up to 12 ft. in diameter. The furnace has an inside length of 80 feet with a complete enclosure. But what ever the size, from small to king-size, F. & D. engineers stand ready to design and construct furnaces to meet your exact requirements. Write for literature on the type of heating equipment you need.

Call the F & D office for more details and FREE information . . . no obligation of course

FLINN & DREFFEIN *Engineering Co.*



New indicating unit makes older machines obsolete

... it's electro balanced

At last, here is the weighing system you need for today's more rigid testing. It's more sensitive — and offers quicker response — than any other system ever built. Just a slight motion at the beam end (see rear view) provides sufficient signal to operate the servo motor . . . and move the poise to establish force equilibrium.

With Riehle's new sensitivity and rapid response plus complete instrumentation, you no longer keep confirming the "errors" that present, inadequate machines may be making. It gives you full flexibility and precision in testing at elevated temperatures as well as at room temperature. The new Electro-Balanced Indicating Unit is available for both hydraulic and screw power testing machines — by Riehle. Mail coupon for Bulletin.

Riehle TESTING MACHINES

A DIVISION OF

American Machine and Metals, Inc.

EAST MOLINE, ILLINOIS

NEW BULLETIN . . . MAIL COUPON

RIEHLE TESTING MACHINES
Division of American Machine and Metals, Inc.
Dept. MP-457, East Moline, Illinois

Please send your free 4-page Bulletin RU-14-56 with full data on the new Riehle Electro-Balanced Indicating Unit.

COMPANY

ADDRESS

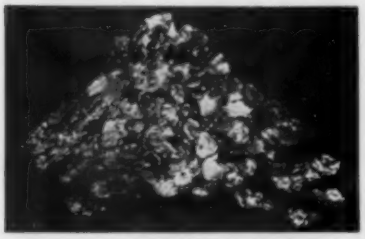
CITY ZONE STATE

ATTENTION MR.

APPLICATION and EQUIPMENT new products

Zirconium

U. S. Industrial Chemicals Co. has announced the availability of reactor-grade and commercial-grade zirconium in the form of platelets and irregular flakelike pieces about the size of dimes and quarters. Platelets are nonpyrophoric, nonhygroscopic, and



extremely pure. They are safe to handle. Zirconium platelets can be compacted for melting as easily as the sponge, and with virtually no waste. They are free of sodium, magnesium, chlorides, hydrogen and moisture.

For further information circle No. 894 on literature request card, page 48-B.

Coloring Copper

Enthone, Inc., has announced a new process for producing brown and shiny blue-black coatings on copper and copper-base alloys. Due to the fact that the finishes formed are oxides, no subsequent crystal spotting occurs. Two-tone effects can be obtained by relieving portions of the oxide coating. Enthocolor 220 is supplied as an alkaline salt mixture and is used at 180 to 225° F. Parts to be colored are given the usual preparatory treatments and are then immersed in the solution for periods of 1 to 15 min.

For further information circle No. 895 on literature request card, page 48-B.

Sonic Gas Analyzer

A gas analyzer employing the velocity of sound has been announced by the National Instrument Laboratories. The instrument contains a long tube in which the velocity of the sound is measured. The gas is fed into the sonic tube at its center and flows out at both ends, so that the velocity of flow does not increase or decrease the rate of sound transmission. Sound waves are generated at one end of the tube and are received by a crystal transducer at the other end. An oscillation frequency of approximately 150 kc. per sec. is used to give high sensitivity. The phase of the received signal is compared with that of the generating crystal and the phase shift is a precise measure of the change in velocity of sound propagation.

For further information circle No. 896 on literature request card, page 48-B.

Anti-Friction Compound

A new all-purpose anti-friction compound has been announced by Lubikold Co. Mixed with cutting oils or emulsions, it adds to the life of tools or dies, permits faster, deeper cutting without excessive heat. For general lubrication purposes, 1 oz. of Lubikold added to each gallon of oil or pound of grease helps reduce friction drag and save wear. It reduces friction by filling up pores and tiny imperfections in contact surfaces.

For further information circle No. 897 on literature request card, page 48-B.

Chilling Chamber

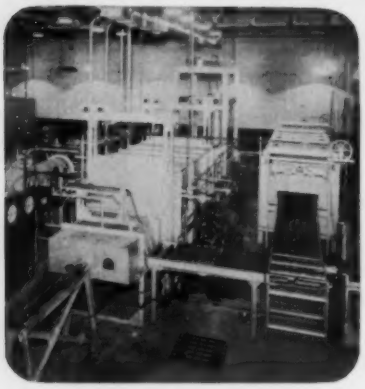
A new chilling machine for testing stability of electric wire insulation has been announced by Cincinnati Sub-Zero Products. The new unit in-

Vacuum Heat Treating

A vacuum heat-treating furnace has been announced by the Pacific Scientific Co. It operates at temperatures from 1300 to 1600° F. under vacuums up to 0.2 microns, and frequently at temperatures in excess of 2000° F. This furnace may be used for a variety of jobs including outgassing reactive metals, heat treating steels, vacuum brazing, diffusion coating and impregnation and aging of precipitation hardening alloys. The unit consists of an electrically-heated furnace with controls and thermocouples to hold temperature variations within close limits, a high-speed diffusion pump, mechanical roughing pump, and a vacuum-tight retort.

For further information circle No. 898 on literature request card, page 48-B.

LABOR SAVED 50%
PRODUCTION UP 50%



R-S . . .
CONTINUOUS HARDENING, QUENCHING, DEGREASING, DRAWING LINE

It's one operation instead of four to heat treat cylinder liners at Continental Motors with the R-S equipment. Electric heat treating line is one complete unit ...temperature is 1575° F. for hardening, it is oil quenched and the draw furnace operates at 1100° F. The atmosphere is controlled through hardening and quenching operations and capacity is 1,300 gross lbs. per hour.

R-S Heat Treating unit requires only two men instead of four with the conventional type. Production rate is up 50% . . . quality is uniformly high . . . and the unit paid for itself in 22 months.

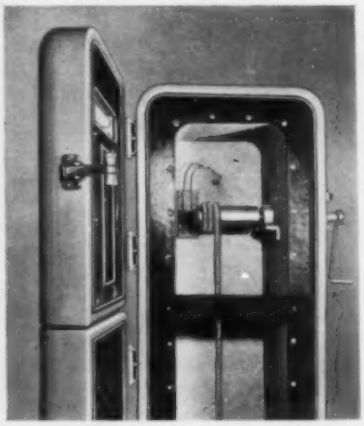
Why not put these savings into your heat treating? Write today for your copy of the booklet on better heat treating. Ask for R-S 200. No obligation.

R-S FURNACE CO., INC.
Philadelphia 44, Pa.

Car Hearth Furnaces
Continuous Furnaces
Rotary Type Furnaces

R-S FURNACES

cludes an air circulator in the door, observation window and lights, as well as fittings for holding a manually rotated mandrel shaft which supports weighted lengths of wire. The chilling unit has temperature adjustment



from —10 to —80° F., and a thermal capacity of 200 Btu. per hr. at —70° F., operating under normal conditions. Two doors, of the low-temperature overlap type, have heavy duty adjustable hinges and latches. The top door, containing a window, overlaps the bottom door tray for a tight seal.

For further information circle No. 899 on literature request card, page 48-B.

Thickness Tester

A new portable nondestructive coating thickness tester has been developed by Unit Process Assemblies, Inc.

Dermitron D-2 comes with four measuring probes for various deposit ranges from thin to thick and requires only a ⅛ in. circle-area for measurement.

For further information circle No. 900 on literature request card, page 48-B.

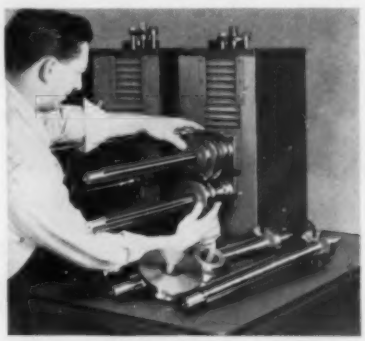
Portable Electroplater

A portable automatic electroplating unit, designed for electrical and other precision components, has been announced by Sel-Rex Corp. Requiring approximately 18 by 38 in. of floor space, in the standard 10, 20 and 30 gal. capacities, the Jet Plater consists of a selenium rectifier with automatic timer, stainless steel tank (which may serve as the anode) fitted with a water jacket for temperature control, a movable work rack which accommodates a portable plating barrel, a centralized control panel, a filter, and pump with motor. The name of the Jet Plater is derived from the method of solution agitation accomplished through a pump and a perforated stainless steel tube at the bottom of the plating tank.

For further information circle No. 901 on literature request card, page 48-B.

Rolling Mill

Interchangeable arbors are featured on the new universal rolling mill announced by Mohawk Metal Forming and Tool Corp. Sizes vary from 1 to 3 in. as needed. Each arbor can be removed in about 5 min. or approximately 140 min. for a fourteen head rolling mill. The mill is powered by a three-phase electric motor which transmits the driving force through

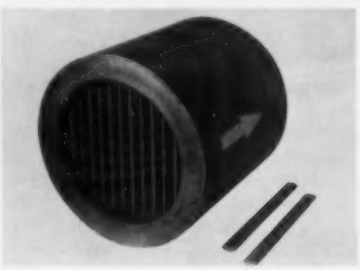


the magnetic clutch and brake thence to the gear boxes, each of which is equipped with herringbone gears. From thence the motivating power is transmitted to the station with each arbor operated by a spiral worm gear which in turn operates a bevel meter gear.

For further information circle No. 902 on literature request card, page 48-B.

Separator

A corrosion-resistant entrainment separator for the removal of liquid particles from air and other gases has been announced by National Carbon Co. It is a self-contained unit ready for inserting in a pipe line. Rods of

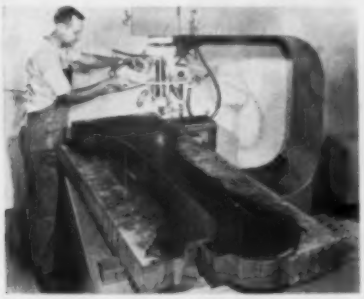


impervious graphite are staggered in rows within the cylinder. Although minimum clearance is ¼ in., which prevents clogging, a beam of light will not pass through. As the gas to be scrubbed flows through the cylinder, moisture particles impinge on the separator rods. The unit can be operated at temperatures ranging from 340° to −40° F., and at pressures from full vacuum to 65 psig.

For further information circle No. 903 on literature request card, page 48-B.

Contour Machining

DoAll Co. has announced a contour band sawing machine for large, un-

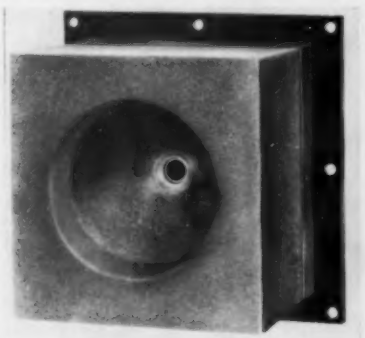


gainly workpieces, in which the tool moves instead of the work. The cutting and guiding mechanism is carried by a yoke housing all the necessary parts for the cutting and the power feed. Between the yoke and the stationary member, which is fastened to the floor, is an intermediate member. These three sections are connected by hinges using anti-friction bearings. The design permits the saw blade to move within a 70 sq-ft. area and to make a straight cut 14½ ft. long.

For further information circle No. 904 on literature request card, page 48-B.

Gas Burner

A new cone-type gas burner which provides a large radiant heat surface and high rate of heat transfer without flame impingement has been announced by Hauck Mfg. Co. The burner features high speed combustion and rapid penetration of the



work by radiant heat, thereby reducing furnace size. It utilizes any commercial fuel gas and provides mixing of air and gas at the stainless steel nozzle outlet.

For further information circle No. 905 on literature request card, page 48-B.

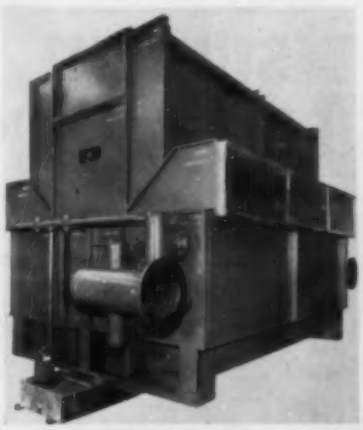
pH Meter

A line-operated pH meter has been announced by Photovolt Corp. Model 85 can be furnished either with individual glass and calomel electrodes or with a probe electrode, a combination of glass and calomel electrodes. Meter is of simple construction and can be used by operators with limited training. Accuracy is 0.1 pH unit.

For further information circle No. 906 on literature request card, page 48-B.

Cooler

Niagara Blower Co. has announced a new self-contained after cooler for cooling and removing the moisture from compressed air and for cooling water in a closed system for intercooler and compressor jackets. The apparatus consists of two parallel mounted cooling coils (one for jacket water and one for compressed air) in



separate casings joined to a central plenum. Sprays of recirculated water constantly drench these coils. Evaporation transfers the heat of compression, at the rate of about 1000 Btu. per lb. of water evaporated, to the air stream. The air enters above the coils, travels down through them and moves into the central plenum dropping its entrained moisture, then turns upward and is ejected by a propeller fan.

For further information circle No. 907 on literature request card, page 48-B.

Extrusion

Allegheny Ludlum Steel Corp. has announced a steel extrusion, now being turned out at the Watervliet

Somers THIN STRIP

.000175" THIN

Now available in production quantities

Keeping pace with the advanced design of transistors and other electronic components, Somers Brass Company has installed a unique mill for the production of ultra-thin strip. Brass, copper and nickel are now being rolled down to .000175", up to 4" wide, in footages to satisfy mass production requirements.

You can rely on Somers, specialists for nearly 50 years, for the experience to solve your thin strip problems, whether in design or manufacturing.

Write for Confidential Data Blank and a complete analysis of your present or proposed application at no cost or obligation.

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Somers

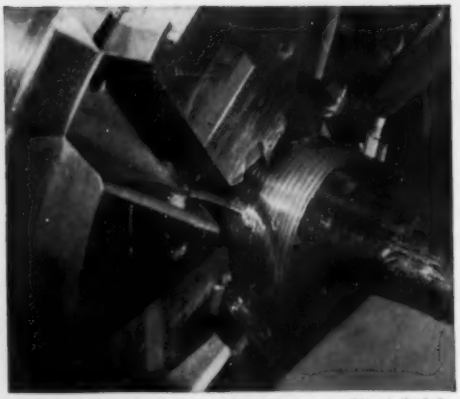
Somers Brass Company, Inc.

106 BALDWIN AVE., WATERBURY, CONN.

JOE IS DETERMINED TO SEE EVERY STEP OF THAT PRECISION CUTTING JOB.
WE'D SAVE MONEY BY GETTING HIM SOME TRANSPARENT SUNICUT.
LOCKE

For precision cutting...

TRANSPARENT SUNICUT OILS ASSURE YOU GOOD VISIBILITY, PEAK PRODUCTION



Transparent Sunicut oils assure excellent finish in critical operations at close tolerances. Good visibility speeds production.

Transparent Sunicut® oils, including heavy-duty and dual-purpose oils, are available in many grades to suit your specific needs. They give outstanding results...especially where precision cutting is required.

Their transparency takes the "blinders" from work that needs close watching, permitting close product control, faster production, lower unit cost. Machine operators like Sunicut's "cleanliness." Most important, *transparent Sunicut oils assure you of good finishes.*

For full information about Sunicut cutting oils, call your Sun representative, or write to SUN OIL COMPANY, Philadelphia 3, Pa., Dept. MP-4.

INDUSTRIAL PRODUCTS DEPARTMENT

SUN OIL COMPANY

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SUNOCO®

©Sun Oil Company

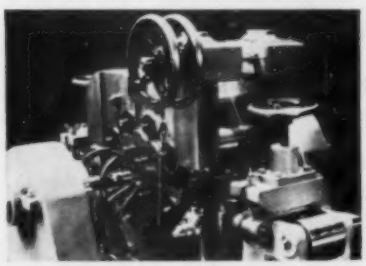
works, that saves an airplane manufacturer 75% in machining time. This airframe section, which is made of SAE 8630 carbon steel, is used in fuselage stringers, previously made of

bar stock. A 25-sq-in. billet is squeezed into a 0.4-sq-in. T-section. Production speeds run up to 45 miles per hour as the extruded shape leaves the press. The billet is extruded at temperatures of about 2250° F. to a thickness of 0.140 in. at a pressure of 150,000 psi. The extruded piece is made in bars 25 ft. in length and then cut to size.

For further information circle No. 908 on literature request card, page 48-B.

Rolling Strip

A new reversing cluster mill capable of rolling strip from about 0.010 to 0.0001-in. thickness has been announced by Loma Machine Mfg. Co. It can be used to roll 18-8 stainless



steel, high-temperature superalloys, silicon steel, molybdenum, beryllium copper, platinum alloys, nickel-iron alloys and similar magnetic materials. The new machine employs work rolls 7/16 by 4 in., ¼ by 4 in. and 5/32 by 3 in. The mill drive can be applied either to the work rolls, the intermediate rolls or the backup rolls. A variable speed range up to 100 ft. per min. is provided. The mill is available in a 12-high design.

For further information circle No. 909 on literature request card, page 48-B.

Finishing Magnesium

Development of two magnesium finishing processes has been announced by Turco Products, Inc. Turcoat 4245-2F is a production-line process for providing corrosion resistance, paint base and abrasion resistance to all forms and alloys of magnesium. The one-package powdered material is mixed with water. The same solution may be used for processing by either direct or alternating current. Hexavalent chromium is the only control required, and the bath is brought back to strength by addition of the original material. Turcoat 4091 is a liquid process for touching-up coating magnesium that has been scratched or abraded. The process, which does not require electrical current, is also used where assemblies are too large to be immersed. The compound is brushed or sprayed onto the surface to be coated.

For further information circle No. 910 on literature request card, page 48-B.

Sawing Machine

S & S Machinery Co. has announced a bandsawing and bandfiling machine in a range of speeds from 45 to 10,000 ft. per min. It will cut such difficult-to-machine materials as stainless steel and manganese steel. The standard Tridraulic comes with a 36 and 48 in. depth of throat with 20 in. vertical capacity under the saw guide. All three saw wheels are enclosed in the body with doors provided for easy access. The table operates on a duplex slide, measures 30 in. wide by 60 in. long, is hydraulically controlled and allows for a 30 in. traverse. The machine can be converted from sawing to filing by the substitution of a filing band for the saw blade.

For further information circle No. 911 on literature request card, page 48-B.

Vacuum System

A new vacuum system for laboratory, pilot plant and limited production use has been announced by the Rochester Div. of Consolidated Electrodynamics. The pumping system includes a three-stage oil diffusion pump and affords a choice of 13, 15, 27 or 130-c.f.m. mechanical pumps for roughing and backing. These pumps

Trade names you can trust!

HOSKINS
Chromel-Alumel
THERMOCOUPLE ALLOYS

■ ACCURACY
■ DURABILITY
■ ECONOMY

Unconditionally guaranteed to register true temperature-e.m.f. values within ±4° from 32°—530°F.; ±¾% from 531°—2300°F.

Highly resistant to oxidation, they maintain their fine accuracy far longer than any other base metal couple material known.

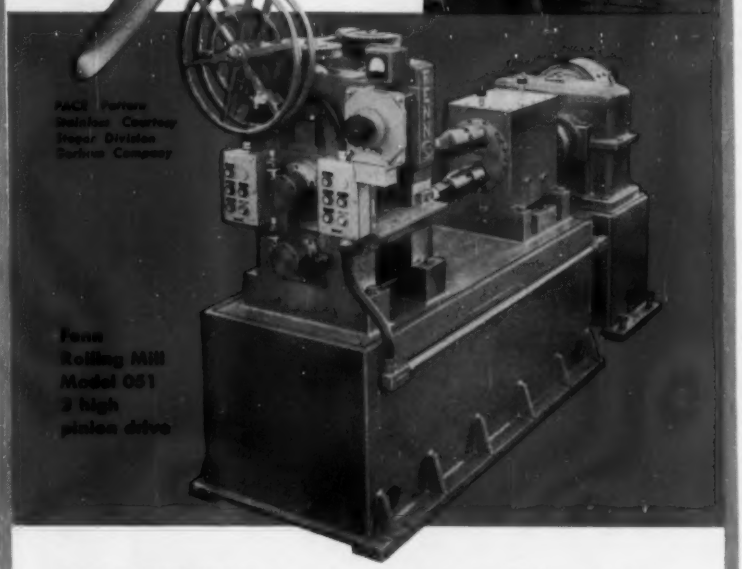
Despite their greater accuracy and longer life, Chromel-Alumel thermocouple wires cost you no more than ordinary wire . . . and in many cases, they actually cost less! So ask for them by name. "Chromel-Alumel" thermocouples . . . *trade names you can trust!*

30-page manual contains useful technical information. Send for it today!

Chromel-Alumel thermocouple alloys are produced exclusively by

HOSKINS MANUFACTURING COMPANY
4445 Lawton Avenue • Detroit 8, Michigan

a pinch that pays on stainless steel



Fenn Rolling Mill Model 051 2 high pinion drive

FENN ROLLING MILLS, because of their flexibility and dependability, have been adopted as standard mills in many vertical segments of the metal working industry. In the manufacture of flatware, for example, Fenn rolling mills are in use by nearly every major producer. These mills are specifically designed to meet the flatware manufacturers' precision requirements for grading, pinch rolling and cross rolling.

The Fenn Model 051 mill, shown above, is in operation at the Stegor Division, The Gorham Company, Providence, R. I. In a two-pass operation, .095 ga. tableware blanks of 430 stainless steel are pinch rolled with .027″ reduction taken on the first pass, and .013″ reduction on the second. Production rate is more than 200 pieces per hour with dimensional tolerances held to ±.001″.

For complete information on Fenn Rolling Mills write for Catalog RM 56 or, better still, let Fenn engineering service study your requirements for specific recommendations.

FENN Rolling Mills

Fenn Manufacturing Co., 502 Fenn Road, Newington, Connecticut

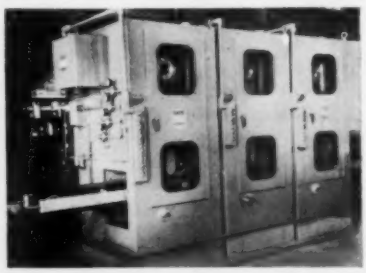
are operated by circuit breakers and are interlocked to prevent improper sequencing. Pump-down time with a clean, dry system is 5 min. to 0.5 micron Hg with an ultimate pressure of 3×10^{-5} mm. Hg. With a fractionating oil diffusion pump substituted

for the three-stage pump, an ultimate pressure of 3×10^{-6} mm. Hg can be reached. Pressures in the work chamber and fore-pressure lines are measured by new discharge and Pirani gages from 2 mm. to 1×10^{-7} mm. Hg. An 18 by 30-in. Pyrex bell jar is the work chamber. It seats on a baseplate which has holes for vacuum-gage sensing tubes, filament heating electrodes and optional accessories.

For further information circle No. 912 on literature request card, page 48-B.

Grinding Machines

Curtis Machine Div. has announced the addition of coated abrasive belts to its line of grinding, polishing and deburring machines. The machine illustrated employs three abrasive belts over one conveyor belt and is



equipped with wet grinding, oil mist applicator, automatic tracking and pneumatic tensioning of the 10-in. wide abrasive belts. A three-grit polishing sequence, three-step stock re-

NEW, Portable Indicator

MINIMITE
Has 23½ Inch Double Scale

Small Size Extremely small and compact, the "MiniMite" Portable Potentiometer Indicator weighs under four lbs. and measures only 4" x 5" x 6".

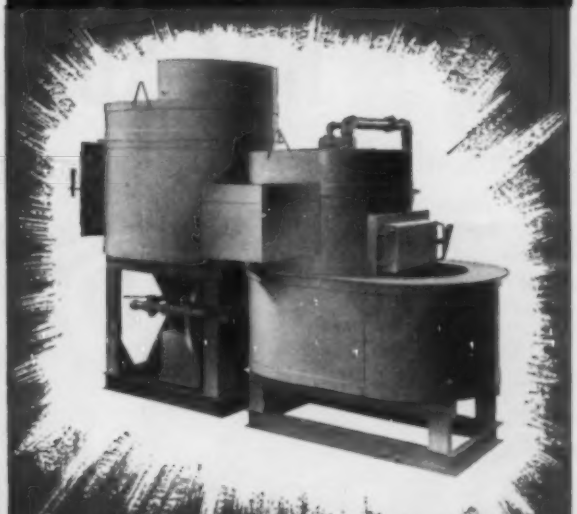
Scale Range Despite its small size the "MiniMite" has a 23½ inch scale. Standard double scale range is 0—1800° F. for Iron-Constantan and 0—2400° F. for Chromel-Alumel. Other scale ranges are also available. Measuring accuracy is ¼% of scale range.

Dual Application The "MiniMite" can measure temperature directly when connected to a thermocouple, or check other potentiometer or millivoltmeter-type instruments when used as a comparison instrument.

Write for Bulletin 64-H.

Thermo Electric Co. Inc.
SADDLE BROOK, NEW JERSEY
In Canada—THERMO ELECTRIC (Canada) Ltd., Brampton, Ont.

HERE'S ANOTHER NEW ONE!



Stroman "DC" Cylinder Type Furnaces for Combination Melting and Holding Aluminum with
CONTAINED COMBUSTION BURNERS

For Die Casting, Permanent Mold and Sand Casting Operations

"Versatility Plus" is the keynote of these newest Stroman Contained Combustion Furnaces. They are absolutely new in design for they incorporate Contained Combustion Burners which eliminate direct flame impingement on the metal. They also make for cooler working conditions because of less heat loss. They give greater fuel economy for less BTU input is required . . . Longest refractory life and least maintenance due to mild combustion conditions . . . Uniform heating condition and improved metal temperature control assure lowest metal losses.

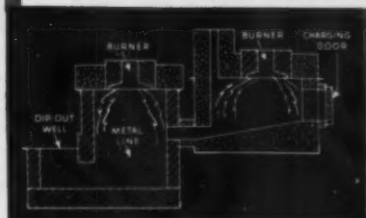
They are easy to charge and readily adaptable to automatic charging. Handling from 450 to 1600 lbs. per hour break down capacity with holding capacity from 600 to 2400 lbs., they will melt metal faster and more economically, and at the same time produce only the highest quality metal.

Roof of the furnaces are easily removed for furnace cleaning, relining, repair or burner service, as burner is mounted in the roof.

These Stroman "DC" Cylinder type furnaces are available in break down and holding combinations. However separate break down and holding units can be purchased. Break down units are often used to augment iron pot, electric and crucible furnace capacities.

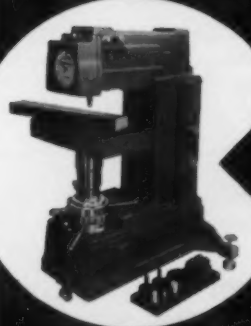
Their flawless operation and ability to deliver years of trouble-free operation stamp them as a leading Stroman Aluminum production furnace. Investigate their cost cutting operation today.

Send for complete new catalogue No. 150 just off the press.



STROMAN
FURNACE & ENGINEERING CO.
FRANKLIN PARK
ILLINOIS

2 Applications (REGULAR AND SUPERFICIAL) 1 Tester



KENTRALL MODEL CT-2

Hundreds of installations over the past few years have proved the economy of the only hardness tester which combines all scales of Rockwell Test (15 to 150 kg. loads).
The Kentrall cuts costs because it does the job of two conventional testers, requires only half the space and maintenance. Write for more detailed information, plus a list of prominent users who have switched to Kentrall.

TB148

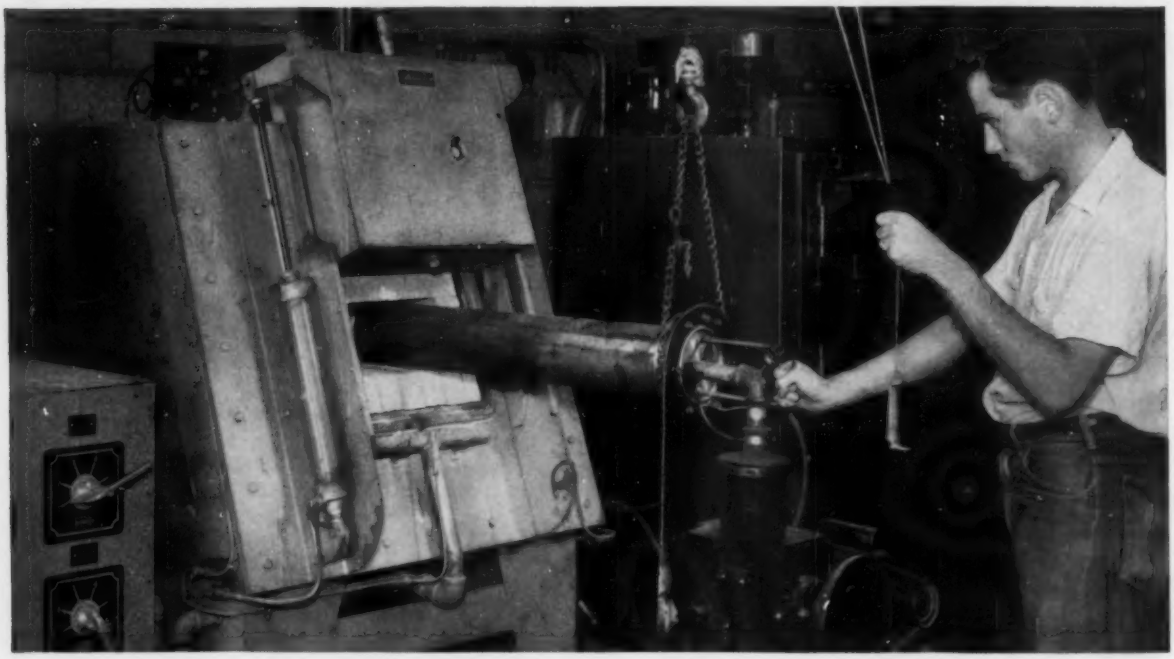
PRICE $680.

KENTRALL
THE TORSION BALANCE COMPANY
Main Office and Factory: Clifton, New Jersey
Sales Offices: Chicago, San Francisco

Electric furnace users and builders report:

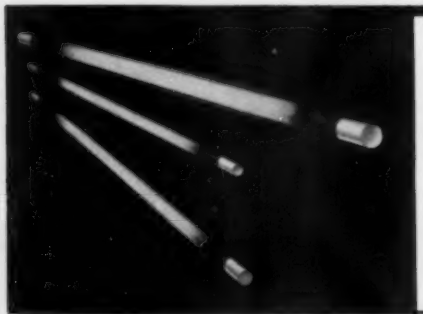
"HOT RODS" PAY OFF!

Progressive firms list advantages of CRYSTOLON* heating elements



Metallurgical Consultants, Inc., of Los Angeles say that "Hot Rods" provide excellent service life for a variety of heat treating applications including vacuum and protective atmosphere work. Their furnace, shown above, is used for heat treating a wide variety of parts. This requires several daily temperature variations, from 1600°F. to 2300°F., causing repeated thermal shocks to the heating elements. Yet the original "Hot Rods" — Norton heating elements — show no signs of failure after more than two years of this especially hard service.

The builders of this furnace, the Pacific Scientific Company of Los Angeles, Calif., are equally enthusiastic. They report that the long and better operating service of "Hot Rods" more than justifies their use in any electric furnace requiring nonmetallic heating elements. As a result, they install these Norton CRYSTOLON heating elements in every furnace of this type they build.



Many plants report that Norton heating elements outlast other nonmetallic elements *up to 3 to 1!* This much longer life means savings in element costs, because fewer elements are needed. Also, you get reduced maintenance, due to less changing of elements or voltage taps. And "Hot Rods" help protect product quality because their slow, evenly matched rate of resistance increase means more uniform heating.

The big, illustrated booklet, *Norton Heating Elements*, gives further facts on how "Hot Rods" can help improve your furnace operations and cut costs. Write for your copy to NORTON COMPANY, Refractories Division, 323 New Bond Street, Worcester 6, Massachusetts.

Norton CRYSTOLON Heating Elements, or "Hot Rods," are a typical Norton ℞ — an expertly engineered refractory prescription for greater efficiency and economy in electric kiln and furnace operations. Made of self-bonded silicon carbide, each rod has a central hot zone and cold ends. Aluminum-sprayed tips and metal-impregnated ends minimize resistance and power loss. Available in standard sizes.

*Trade-Mark Reg. U.S. Pat. Off. and Foreign Countries

NORTON
REFRACTORIES
Engineered... ℞ ...Prescribed

Making better products... to make your products better

NORTON PRODUCTS:
Abrasives • Grinding Wheels
Grinding Machines • Refractories

BEHR-MANNING PRODUCTS:
Coated Abrasives • Sharpening Stones
Behr-cut Tapes

moval or combination of polishing and grinding is possible.

For further information circle No. 913 on literature request card, page 48-B.

Portable Furnace

Hevi-Duty Electric Co. has announced the construction of a portable furnace for heating titanium for forming. The operation required a furnace in which both form block and titanium could be heated before being placed on the hydropress transfer table for forming. The furnace has a chamber 24-in. high by 50 in. wide by 72 in. deep to accommodate flat sheets

as well as partially formed details. It is divided into two sections by a removable alloy steel screen shelf. The shelf is capable of supporting 50 lb. and the floor 250 lb. The furnace has a temperature range of 400 to 1250° F. All controls are an integral part of the furnace. The double end furnace can be worked from either end, thus lending itself to production run with transfer crews working at both ends.

For further information circle No. 914 on literature request card, page 48-B.

Steam Cleaning

An injector unit that uses existing steam supplies for cleaning, paint stripping and phosphating has been announced by Turco Products. The Steamerette will operate anywhere in the range of 40 to 140 psi. steam. A built-in pressure gage indicates the operating pressure and eliminates fluctuating. Quantity and pressure of solution at the nozzle may be varied to provide every type of delivery from a slow full stream at moderate temperature to a hot driving blast for heavy cleaning.

For further information circle No. 915 on literature request card, page 48-B.

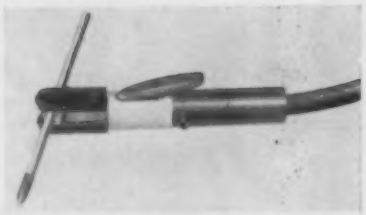
Dilatometer

Two new Chevenard dilatometers have been announced by R. Y. Ferner Co. One is a mechanically recording instrument for an operating range from 0 to 3000° F., especially developed for studies in metals and ceramics. The other is a photographic dilatometer, constructed to process specimens sealed in controlled atmospheres or in vacuum. It provides for operating by direct dilatation or differential dilatation techniques. It is equipped with several amplifying heads. Operating range is to 2100° F.

For further information circle No. 916 on literature request card, page 48-B.

Cutting Torch

Arcair Co. has announced a redesigned Arcair Model H-3 cutting torch which is short and compact. The



new H-3 uses only an electric arc and compressed air to cut, gouge, groove or bevel any metal. New features are heat and impact resistant molded plastic insulators, push-button air valve that is insulated and doesn't need to be held down, glass laminate sleeve which protects handle from burning, molded upper arm handle which fits hand, and cable connection inside handle.

For further information circle No. 917 on literature request card, page 48-B.

Sheet Polishing

Brush-sanding drums ranging from 37 to 74 in. in width for sanding or polishing wide metal sheets have been announced by Merit Products. A series of fibre brushes spaced around the circumference of the drum back up a series of abrasive strips that feed out from inside the drum and wipe the abrasive against the stock. The abra-

MANUFACTURED BY MAKERS OF WILSON "ROCKWELL"—
"THE WORLD'S STANDARD OF HARDNESS TESTING ACCURACY"
WILSON "TUKON"
MICRO-HARDNESS TESTERS

Unexcelled for testing fine precision parts

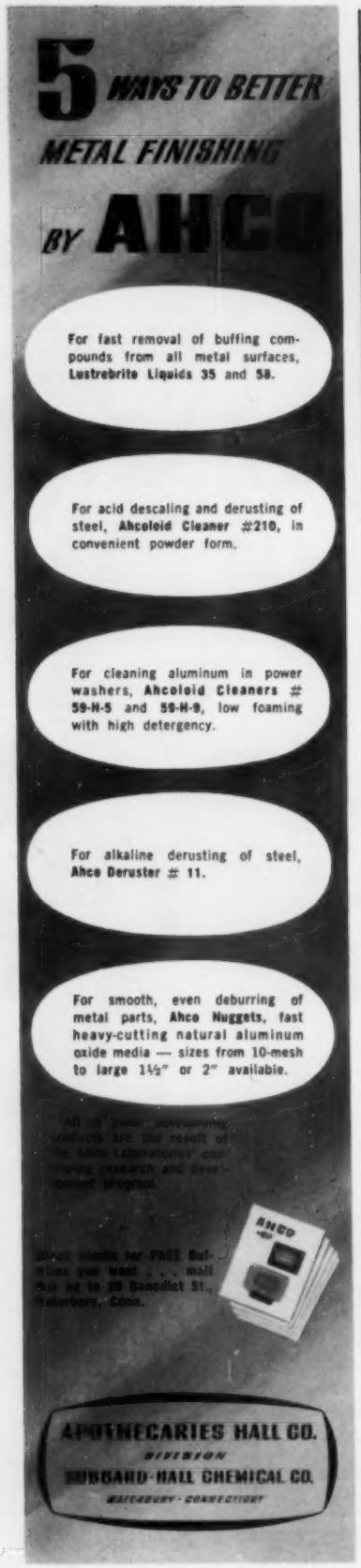
WILSON "TUKON" Micro-Hardness Testers are invaluable for proper testing of fine wire, thin metal, shallow superficially-hardened surfaces, small components, surface coatings, jewels, plastics, glass, etc. Operate with both Knoop and 136° Diamond Pyramid Indentors. Experienced WILSON engineers will help select the specific model required.

Wilson Mechanical Instrument Division
AMERICAN CHAIN & CABLE

230-F Park Avenue, New York 17, N. Y.

ACCO

Write for Booklet DH-328 for complete information of WILSON "TUKON" Micro and Macro Hardness Testers.


5 WAYS TO BETTER
METAL FINISHING
BY AHC
For fast removal of buffing compounds from all metal surfaces, Lustrebrite Liquids 35 and 58.
For acid descaling and derusting of steel, Ahcoloid Cleaner #210, in convenient powder form.
For cleaning aluminum in power washers, Ahcoloid Cleaners # 59-H-5 and 59-H-9, low foaming with high detergency.
For alkaline derusting of steel, Ahco Deruster # 11.
For smooth, even deburring of metal parts, Ahco Nuggets, fast heavy-cutting natural aluminum oxide media — sizes from 10-mesh to large 1½" or 2" available.
AHCO
APOTHECARIES HALL CO.
DIVISION
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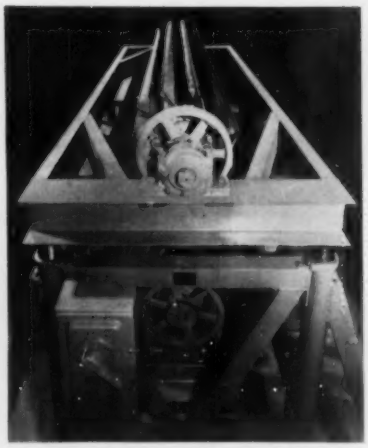
WATERBURY · CONNECTICUT



sive sands low areas without the necessity of grinding down high spots. New abrasive is fed out of the drum as required.

For further information circle No. 918 on literature request card, page 48-B.

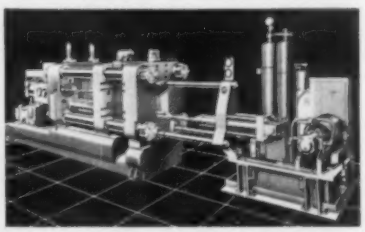
Welding Electrodes

A new high strength, ductile electrode and filled rod developed for the repair and fabrication of a new manganese aluminum bronze casting alloy has been announced by Ampco Metal, Inc. Weld deposits made with the metal-arc process have 95,000 psi. ultimate tensile strength, 42,000 psi. yield strength, 26% elongation in 2 in. and Brinell hardness of 170 to 190. Because of the relatively high manganese, nickel and iron contents, the alloy deposit closely resembles the color of steel, making it adaptable for use in the repair welding of the high strength cast irons.

For further information circle No. 919 on literature request card, page 48-B.

Die-Casting Machines

The Hydraulic Press Mfg. Co. has announced a line of high-pressure, cold-chamber die-casting machines in 200, 400, 600, and 800-ton capacities.



The clamp link-wedge locking mechanism, plus the extra heavy platens and tie rods, locks and pre-loads dies to rated tonnage. Heavy control screw adjustment is motorized and has push button operation for quick die set-up and tonnage control.

For further information circle No. 920 on literature request card, page 48-B.

Cleaner for Aluminum

A new, nonfoaming cleaner which removes identification inks, grease, oils and other heavy soils from aluminum has been announced by Oakite Products. Oakite aluminum cleaner No. 164 is used at 6 to 8 oz. per gal. of water, at temperatures between 160 and 180° F.

For further information circle No. 921 on literature request card, page 48-B.

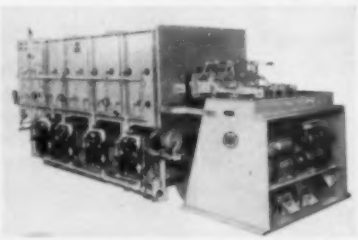
Pressure Transmitter

A new indicating pressure transmitter for pneumatic transmission of process pressure measurements has been announced by the Foxboro Co. It measures pressures of 0 to 30 in. of water to 0 to 6000 psi., transmitting a 3 to 15 psi. air signal to indicating, recording or controlling instruments. To accommodate the various ranges, a choice of pressure elements is offered —spirals, helicals, bellows and diaphragms. Element materials are available for corrosive process fluids. The transmitter has an eccentric indicating scale, 4⅛ in. long, built into the front of the case.

For further information circle No. 922 on literature request card, page 48-B.

Furnace

American Gas Furnace Co. has announced a new shaker furnace with



twin hearths, which double the heat treating production of the same work or heat treat two different types of parts which require the same atmosphere for processing at the same or different time cycles. Automatically operated, these twin hearths are each intended to process up to 800 lb. of work per hour.

For further information circle No. 923 on literature request card, page 48-B.

Laboratory Equipment

Fisher Scientific has announced a portable work-space, 3 by 2 by 2⅓ ft.,

The very high strength of USS "T-1" Steel has helped Athey Products Corporation, Chicago, Illinois, to solve the problem of providing a high-volume trailer for hauling lightweight materials such as bauxite ore. This new rear-dump trailer is bigger than conventional units, yet...

WEIGHS 3½ TONS LESS

The very high yield strength of USS "T-1" Steel—90,000 psi minimum—enabled Athey to increase working stresses and reduce the thickness and weight of drawbar and draft frame structure and of all load-containing body plates. As a result, this unit weighs just 26,000 pounds—7,000 pounds less than conventional units—and, consequently, it . . .

TRAVELS FASTER

It can make empty trips much faster . . . can negotiate steep grades in one higher transmission speed than conventional units. Even with a full load of 35 tons, this lightweight unit can climb 14% grades in second gear. By reducing weight, USS "T-1" Steel speeds operations, cuts non-productive time, and makes possible a larger trailer that...

CARRIES MORE PAYLOAD

This trailer has the lowest ratio of vehicle weight to load weight ever designed . . . and carries a full 30.5 cu. yds.—8 yards more than conventional units of the same weight-carrying capacity. It promises to increase, materially, the efficiency of hauling *lightweight* materials . . .

THANKS TO USS "T-1" CONSTRUCTIONAL ALLOY STEEL

USS "T-1" Steel's toughness and resistance to impact abuse assure Athey the ruggedness and durability needed in off-road mountain service. Its excellent weldability kept fabrication simple.

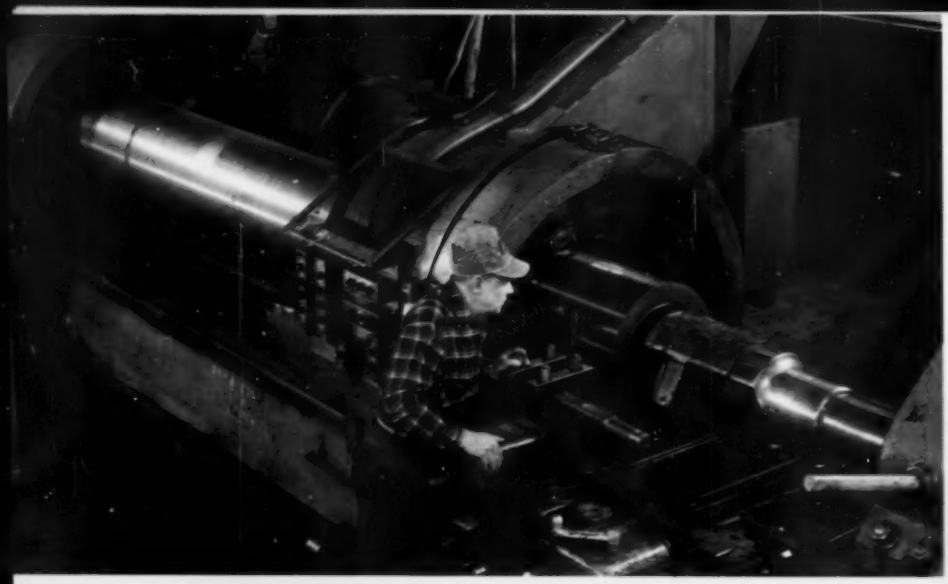
USS "T-1" Steel can help you in a wide variety of heavy-duty applications. Get complete facts—call our nearest sales office, or write to: United States Steel, 525 William Penn Place, Pittsburgh 30, Pennsylvania.

USS

See The United States Steel Hour. It's a full-hour TV program presented every other week by United States Steel. Consult your newspaper for time and station.

UNITED STATES STEEL CORPORATION, PITTSBURGH • COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO • TENNESSEE COAL & IRON DIVISION, FAIRFIELD, ALA.
UNITED STATES STEEL SUPPLY DIVISION, WAREHOUSE DISTRIBUTORS, COAST-TO-COAST • UNITED STATES STEEL EXPORT COMPANY, NEW YORK

UNITED STATES STEEL



Roll is shown at Homestead Forgings Division of United States Steel being bored, prior to heat treatment and reaming. Machine is 48'' center drive, double end boring lathe.

Glass melting tank is at left. Forged Stainless rolls squeeze the viscous glass between them before it enters annealing lehr. ▼

PPG rolls glass at 2000°F with USS Stainless Steel rolls

In a sizzling race to keep up with the demand for flat glass, Pittsburgh Plate Glass Company is rapidly building new factories and increasing the output of old ones. But you cannot increase the output of an existing factory unless you can somehow get more glass from the melting tanks.

Since plate glass must pass between a pair of rolls as it emerges from the tank, the rolls must turn faster when production is increased. If they turn faster, it is more difficult to dissipate the heat from the molten glass. The answer is better rolls. And when you're thinking in terms of better rolls for hot work, stainless steel forgings are the answer.

Pittsburgh Plate has found that USS Quality Forging rolls have suitable physical properties and microstructure that are so necessary for this job. They are made from Type 410 Stainless Steel, and are remarkably resistant to surface cracking and checking. The rolls are water cooled internally, and there is naturally a steep temperature gradient from O.D. to I.D. The forged rolls resist pitting and oxidation. They retain their dimensions during the 24-hour-a-day glassmaking process.

Pittsburgh Plate has had one set of these rolls in continuous service for two years, and they have already produced *millions* of square feet of glass. Similar rolls will also be installed in their revolutionary new Cumberland, Md. plant.

Write today for our free booklet that describes USS Quality Forgings. Address inquiries or requests for the booklet to United States Steel, Room 2801, 525 William Penn Place, Pittsburgh 30, Pa.

USS QUALITY FORGINGS

USS

heavy machinery parts—carbon, alloy, stainless
forged steel rolls and back-up roll sleeves
electrical and water wheel shafts
specialty forgings of all types

UNITED STATES STEEL

To meet rugged service conditions– a refractory concrete dome made with ATLAS LUMNITE* CEMENT

Three-year service life was obtained at this plant by a previous furnace dome made with the same materials. This 17' diameter hardening and annealing furnace inner dome is made with a castable refractory containing Atlas Lumnite cement — A.P. Green "Kast-Set." Heat passes through 289 easily formed 5" round holes, heating concrete on both sides. Installed by Lindberg Combustion, Chicago, Ill., for the Englander Co., Inc., Birmingham, Ala.

- Lumnite-made refractory concrete resists extreme variations in temperature and thermal shock due to rapid heating and cooling.
- Durability under severe operating conditions is assured.
- Placement is fast and easy — service strength is reached within 24 hours.

For maximum convenience, use Lumnite-made castables. These are pre-mixed, ready for use, and are made by leading manufacturers of refractories. For more information, write: Universal Atlas, 100 Park Avenue, New York 17, N. Y.

UNIVERSAL ATLAS CEMENTS

USS

* "LUMNITE" is the registered trademark of the calcium-aluminate cement manufactured by Universal Atlas Cement Company.

L-145

UNIVERSAL ATLAS CEMENT COMPANY—member of the industrial family that serves the nation—**UNITED STATES STEEL**

OFFICES: *Albany · Birmingham · Boston · Chicago · Dayton · Kansas City · Milwaukee · Minneapolis · New York · Philadelphia · Pittsburgh · St. Louis · Waco*

- SIMPLE, COMPACT DESIGN
- LOW INITIAL COST
- SUPERIOR ADSORBENT
- CONTINUOUS OPERATION
- RAPID REACTIVATION
- MINIMUM MAINTENANCE

...NEWEST CONCEPT IN AIR AND GAS DRYING

UNIQUE DESIGN CONCEPT utilizes super-induced conduction to obtain continuous operation without the use of blowers, heat exchangers, or separate purge gases. This lowers initial cost without loss of operational efficiency and also minimizes maintenance requirements.

This NEW MOLECU-DRYER was designed in the Hayes Laboratory where constant research is quick to recognize the advantages of new developments and apply them to broaden or improve the wide line of "Certain Curtain" electric heat treating furnaces and allied equipment.

USING *Linde* TRADE MARK MOLECULAR SIEVES

Registered Trade-Mark of Union Carbide

HIGH TEMPERATURE DRYING to dew points of minus 100°F or better possible through simplified, completely self-contained MOLECU-DRYER design built to utilize the superior adsorbent properties of *Linde* Molecular Sieves, recently developed by Linde Air Products Company, a Division of Union Carbide and Carbon Corporation.

REQUEST complete data on this new Hayes "Certain Curtain" MOLECU-DRYER. Act today . . . to discover what this totally new concept in air and gas drying can do for you!

C. I. HAYES, INC. ESTABLISHED 1905

MOLECU CERTAIN CURTAIN DRYER

800 WELLINGTON AVE.
CRANSTON 10, R. I.

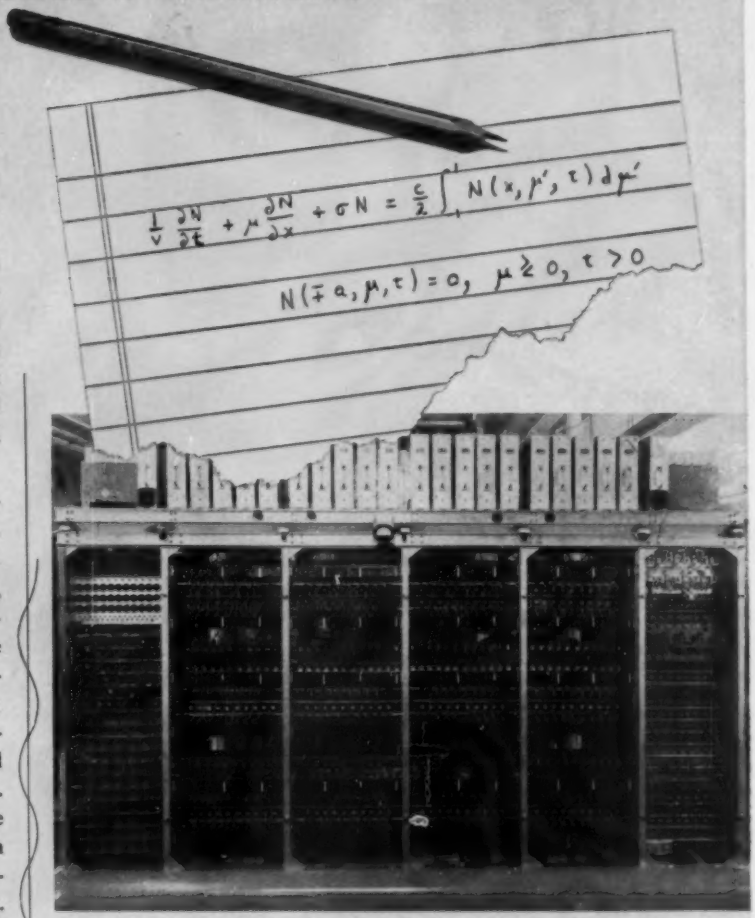
THE PIONEER in controlled-atmosphere (Certain Curtain) electric heat treating equipment.

another example of exciting work at los alamos...

BREAKING PROBLEM BARRIERS

The linearized Boltzmann equation shown at the right describes the transport of neutrons in a slab. Its mathematical structure was first completely worked out at Los Alamos. This is only one of the many fundamental problems in disciplines ranging from pure mathematics through biology that are yielding to newly developed methods of experimental and theoretical analysis.

The Laboratory has entered a new phase of scientific endeavor. Pioneering activities in the unexplored realms of nuclear power, nuclear rocket engines, and controlled thermonuclear power have been added to its weapons program; experiments are being planned and carried out at pressures and temperatures far beyond any previously created by man. These activities exemplify the imaginative approach by which the Laboratory maintains its preeminence in scientific achievement.

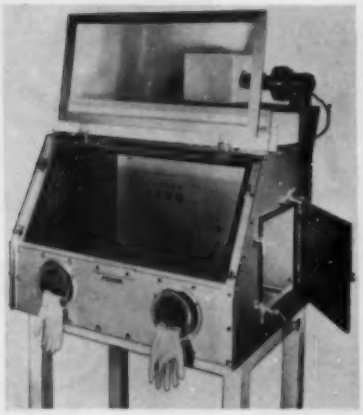

$\frac{1}{v}\frac{\partial N}{\partial t} + \mu\frac{\partial N}{\partial x} + \sigma N = \frac{c}{2}\int_{-1}^{1} N(x,\mu',t)\,d\mu'$
$N(\mp a, \mu, t) = 0, \quad \mu \gtrless 0, \quad t > 0$

Mathematical support for many of the Laboratory's programs is given by the Theoretical Division, which also pursues its own investigations in hydrodynamics, magnetohydrodynamics, computer theory and design, and other fields. The vast amount of computation involved has brought about the creation at Los Alamos of the largest known computing center devoted exclusively to scientific work.

The "Maniac" (above) is one of the many advanced computers in use at the Laboratory.

Los Alamos Scientific Laboratory is a non-civil service operation of the University of California for the U. S. Atomic Energy Commission.

los alamos
scientific laboratory
OF THE UNIVERSITY OF CALIFORNIA
LOS ALAMOS, NEW MEXICO



in which laboratory procedures can be concentrated, confined and controlled. It has its own air supply, exhaust system and services, and is adjustable to meet any air demand. The basic chamber is constructed of 16-gage stainless steel, and has some 20 components, including a Pyrex-glass viewing panel, exhaust air valve, inlet filter, duct system, rubber gloves, swinging-door panel, fluorescent light, mobile stand and power and cable and service assemblies.

For further information circle No. 924 on literature request card, page 48-B.

Control Equipment

West Instrument Corp. has announced fully wired and equipped control units available on a custom

basis or stock basis. Cabinets are wall or floor types, all steel with baked enamel finish, safety interlocked doors, fully wired and diagrammed.

For further information circle No. 925 on literature request card, page 48-B.

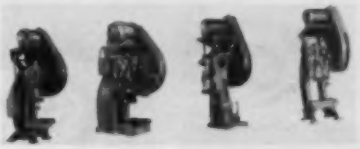
Rust Preventive

A corrosion-protective oil has been announced by Octagon Process, Inc. Polished metal parts treated with Froil under humidity box testing have withstood 100% humidity at 120° F. for over two months without rusting. Froil may be used for protecting precision parts, castings, dies, tools, gages and highly machined and polished parts during their manufacture, storage and shipment. As a water displacing agent, it lifts moisture from crevices to the surface where it will run off.

For further information circle No. 926 on literature request card, page 48-B.

Bench Presses

A new line of bench presses for the electronic, electrical and light metalworking industries has been announced by E. W. Bliss Co.'s San Jose, California Div. The line includes a 4-ton adjustable bed and horning press, 4 and 7-ton inclinable presses and a 10-ton fixed bed press. A long slide, renewable ball seats and bronze-ball-cap bushings, cast Meehanite

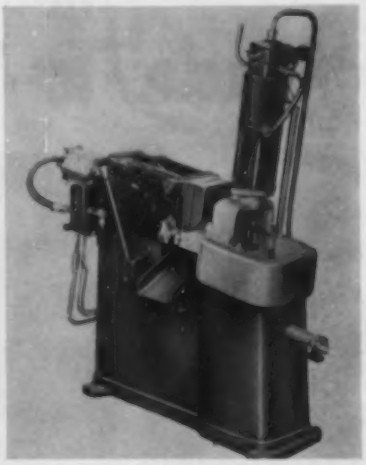


frames, split-bronze bearings, and removable V-type gibbing are featured.

For further information circle No. 927 on literature request card, page 48-B.

Die-Casting Machine

A new model of high speed die-casting machine has been announced by

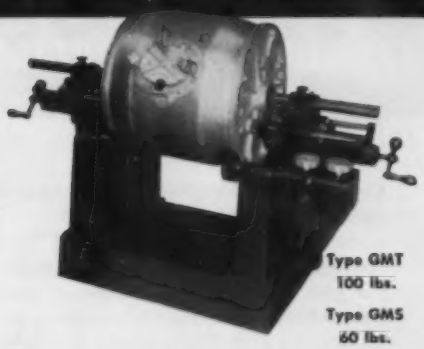


the British Machines and Foundry Supplies, Ltd. The new IMP/96 has a maximum shot capacity of 1 lb., and it can cycle continuously at free cycling speeds up to 3000 shots per hour. It is designed in units so that any part of the machine can be removed and replaced.

For further information circle No. 928 on literature request card, page 48-B.

For Research and Small Production

Detroit GM Series ROCKING Electric Furnaces



Type GMT 100 lbs.

Type GMS 60 lbs.

With these Detroit Rocking Electric Furnaces, you can melt small quantities of any ferrous or non-ferrous alloy to the required analysis quickly, economically. Indirect arc melting provides accurate heat control plus minimum carbon pickup. Automatic rocking action assures homogeneous alloying, full heat utilization and longer lining life. Electrodes are independently mounted for easy shell interchange. Types GMS and GMT Furnaces are sold complete with transformers, ready for installation. Write today for full information.

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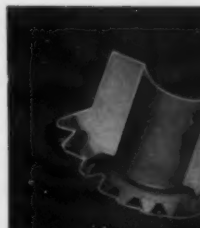
Here's selective heat treating that can be Made-To-Your-Measure!

flamatic *flame hardening*

inductron *induction hardening*

Transmission pinion pin

Locking pin



Bevel gear

Steering arm ball stud

Locking pawl

Cincinnati does both—selective flame or induction hardening—and the parts shown at right are typical of those that can be hardened by either method. If that's your situation, then talk to Cincinnati . . . headquarters for equipment that gives you the hardness wanted, where it's wanted, using the heat source most economical for you. Use electric power—or acetylene, propane, natural or manufactured gas—whichever is readily available to you or provides lowest cost.

Whether flame or induction, you can be assured of heat-treating machinery that will deliver the hardness you specify, and meet your cost-per-piece requirements, on high production quantities or varied, small-lot runs. It will be excellently engineered, equipped with the finest of components, thoroughly safeguarded, easily maintained.

Call in a Process Machinery Division field engineer. He is ideally equipped to evaluate your needs and give you unbiased recommendations as to the most economical equipment for your selective surface hardening work.

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flamatic and inductron *hardening machines*

THE PROCESS MACHINERY DIVISION
THE CINCINNATI MILLING MACHINE CO.
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APPLICATION and EQUIPMENT new literature

930. Abrasion Tester
Bulletin 5409 on new model standard abrasion testing set describes machine and its operation. *Taber Instrument Corp.*

931. Abrasive Cleaning
Catalog 54-W on brush types, sizes, speeds, filaments. Aids to power brush selection. *Pittsburgh Plate Glass, Brush Div.*

932. Abrasive Wheels
New 74-page abrasive wheel safety code includes scope and definitions, handling, storage, inspection, general machine requirements, safety guards, flanges, mounting, speed and general operating rules. *Grinding Wheel Institute*

933. Abrasives
18-page catalog 556 on various types of shot and grit abrasives. SAE specifications and types of cleaning and peening methods. *Cleveland Metal Abrasive*

934. Alloy Castings
22-page bulletin 2041 on heat and corrosion resistant castings. *Blaw-Knox*

935. Alloy Steel
14-page bulletin on two chromium-nickel alloy steels. Properties, working instructions, heat treatment, recommended uses. *Carpenter Steel*

936. Alloy Steel
Data book on the selection of the proper alloy steel grades for each manufacturer's needs. *Wheelock, Lovejoy*

937. Alloy Steel
16-page book on type 9115 low-alloy high-strength steel. Properties, fabrication, welding. *Great Lakes Steel*

938. Aluminum Castings
Compilation of data on the Antioch process for making aluminum castings. Variety of castings described and method of casting by this process. *Morris Bean & Co.*

939. Aluminum Die Castings
Bulletin on design and manufacture of aluminum die castings. *Hoover Co.*

940. Aluminum Extrusions
Folder lists alloys used, finishes, trade phraseology. *General Extrusions, Inc.*

941. Ammonia
8-page booklet on uses of dissociated ammonia in industry. Dissociation process and applications in bright annealing, furnace brazing, powder metallurgy, bright hardening. *Armour Ammonia Div.*

942. Ammonia Atmospheres
12-page bulletin B-52 on dissociated ammonia furnace atmospheres. *Drever*

943. Annealing
4-page reprint No. 62 on salt bath annealing of cold finished sections. *Ajax Electric*

944. Anodes
8-page bulletin on copper, brass and bronze anodes for acid-copper plating. *American Brass Co.*

945. Arc Furnaces
Flexibility of the electric arc furnace—what it means to the steel producer, in Carbon and Graphite News. *National Carbon*

946. Automatic Control
40-page catalog No. 4A shows design and various models of contact metal relays. *Assembly Products*

947. Barrel Finishing
20-page catalog of equipment and supplies. Abrasive and burnishing media. Variables in barrel finishing. *Globe Div., Casalbi Co.*

948. Beryllium Copper
12-page booklet on casting alloys. Properties of alloys and castings. How Be-Cu castings are made. *Beryllium Corp.*

949. Bimetal Applications
44-page booklet, "Successful Applications of Thermostatic Bimetal", contains uses, formulas, calculations. *W. M. Chace*

950. Black Oxide Coatings
8-page booklet on black oxide coatings for steel, stainless steel and copper alloys. *Du-Lite*

951. Blast Cleaning
24-page catalog 1210 on equipment and accessories for blast cleaning and dust control. *Pangborn*

952. Brass Ingots
16-page booklet on new brass and bronze ingot produced by C.P. process. *I. Schumann & Co.*

953. Brazing
20-page reprint GER-106 on electric furnace brazing tells how it is used with pressed metal parts, to simplify product design and for assembly. *General Electric*

954. Brazing
28-page catalog of brazing and soldering equipment with suggestions on setting up brazing lines to fit the product being joined. *C. M. Kemp*

955. Burners
Bulletin 212 on dual-fuel burners for oil or gas. Combustion characteristics, burner operation, burner construction, piping. *North American Mfg.*

956. Calibrating Machine
Bulletin 115 on calibrating system for accurate measurement of mechanical forces. *Morehouse Machine*

957. Carbon and Graphite
20-page catalog on carbon and graphite applications in metallurgical, electrical, chemical, process fields. *National Carbon*

958. Carbon Control
16-page bulletin on equipment for carbon and sulphur determination, including combustion furnaces and other accessories. *Harry W. Dietert*

959. Carbon Refractories
New catalog section on carbon products for cupola furnaces gives physical properties of carbon refractories and describes applications. *National Carbon*

960. Carburizer
Data sheet on Perliton 400, water soluble carburizer. Operation of bath. Case depths. *E. F. Houghton & Co.*

961. Carburizing
5-page review of salt bath carburizing. Practical and fundamental advances. *American Cyanamid*

962. Carburizing
Bulletin on carburizers for pack carburizing. *Park Chemical*

963. Case Hardening
Handbook on Nitrocycle case hardening and how it reduces finishing costs. *Oil Well Supply Div., U.S. Steel*

929. Spring Steels
This 48-page booklet is designed to give information needed in the selection of spring steel. It contends that a knowledge of how the steel is made is essential in selection and includes descriptions of control of raw materials, rolling, annealing, slitting, filing, hardening and tempering, and polishing. Hard-

ness values of spring steel are considered. Photomicrographs show hot rolled, annealed and tempered structures and illustrate effect of grain in steel. Physical property data is given by means of charts, with instructions on how to use them. *Wallace Barnes Steel Div., Associated Spring Corp.*

964. Castings
New 16-page booklet, "Cast to Outlast Destructive Service", gives latest information and case histories on use of sand, centrifugal and precision investment castings. *International Nickel Co.*

965. Centrifugal Castings
Folder on which centrifugal castings are available. Compositions, properties, standard designations. *Sandusky Foundry and Machine Co.*

966. Ceramic Tools
10-page report on machining steel with

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ceramic tools includes grinding ceramic tools, new-type tool holder, geometry of ceramic tools. *Norton*

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Literature on single-package products to produce coatings equal to Dow No. 17 and Dow No. 18, and nonelectrolytic process for removing chrome pickle film from magnesium. *Turco Products*

968. Chromium Plating
4-page bulletin on new "crack-free" chromium plating process. *United Chromium Div., Metal & Thermit*

969. Chromizing Process
8-page bulletin on corrosion resistance of chromallized iron and steel. *Chromalloy*

970. Cleaning
Data on ultrasonic cleaning equipment gives specifications and operation. *Branson Ultrasonics*

971. Cleaning
28-page catalog, B-9, on corrosion-resistant baskets, racks, crates and tanks and other fixtures for cleaning and finishing. *Rolock*

972. Cleaning
Folder on steel shot for cleaning aluminum castings, gray iron castings, steel forgings and for shot peening. *Steel Shot Producers, Inc.*

973. Cold Finished Steel
16-page booklet on 10 grades of cold finished steels. Analysis, machinability, heat treatment, wear resistance. *Jones & Laughlin*

974. Compressors
12-page data book 107-D gives engineering information on characteristics of turbo-compressors. 18 types of application described. *Spencer Turbine*

975. Continuous Furnaces
New 4-page bulletin SC-177 gives specifications, process recommendation and application examples. *Surface Combustion Corp.*

976. Controlled Atmospheres
Bulletin 753 on generator for atmospheres for hardening, brazing, sintering and annealing carbon steels. *Hevi Duty*

977. Controlled Atmospheres
Illustrated literature describes controlled atmosphere installations. *Gas Atmospheres, Inc.*

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8-page bulletin G15-1 on transmitting, recording, indicating and controlling instruments. *Bailey Meter Co.*

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56-page catalog 857 of automatic controls for heating and industrial applications—pressure, temperature, liquid level, etc. *Mercoid Corp.*

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Report on service life of woven wire conveyor belts operating at temperatures of 2050° F. *Cambridge Wire Cloth Co.*

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Catalog on compounds for rolling, blanking, forging, extrusion, stamping, drawing, cutting and grinding. Cleaning, etching and stripping chemicals. *International Chemical Co.*

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994. Descaling
Bulletin on system of descaling stainless, alloy steels and titanium after heat treating. *Kolene Corp.*

995. Descaling
Bulletin 1184 on descaling salt for desanding and cleaning castings. *Hooker Electrochemical*

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Data sheets on molten bath descaling and cleaning. *Swift Industrial Chemical*

997. Descaling Equipment
36-page booklet on hydraulic descaling equipment. Operating principles. Specifications. *Commercial Shearing and Stamping Co.*

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16-page bulletin on Chevenard dilatometers for laboratory use. Principles of operation, components. *R. Y. Ferner Co.*

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Folder on electric furnaces with zone control, temperature indication, automatic control. *L & L Mfg. Co.*

1001. Electric Furnaces
16-page Bulletin No. 559 on melting, investment casting and other furnaces. Capacities and special features. *Detroit Electric Furnace*

1002. Electric Furnaces
Data sheet describes and gives specifications of standard non-metallic resistor furnaces. *Harrop Electric Furnace Div.*

1003. Electric Furnaces
Bulletin on electric heat treating furnaces gives summary of progress in furnace developments. *Holcroft*

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8-page Bulletin 570 on heat treating, melting, metallurgical tube, research and sintering furnaces. Custom designs for special requirements. *Pereny*

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8-page bulletin on new wire materials—Nickelply and Brassply, electrocoated steel wire. How it may be formed bent and twisted without breaking the coating. *National Standard*

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1015. Flow Meters
Bulletin 203 on flow meter for gas used in heat treating. *Waukee Eng'g*

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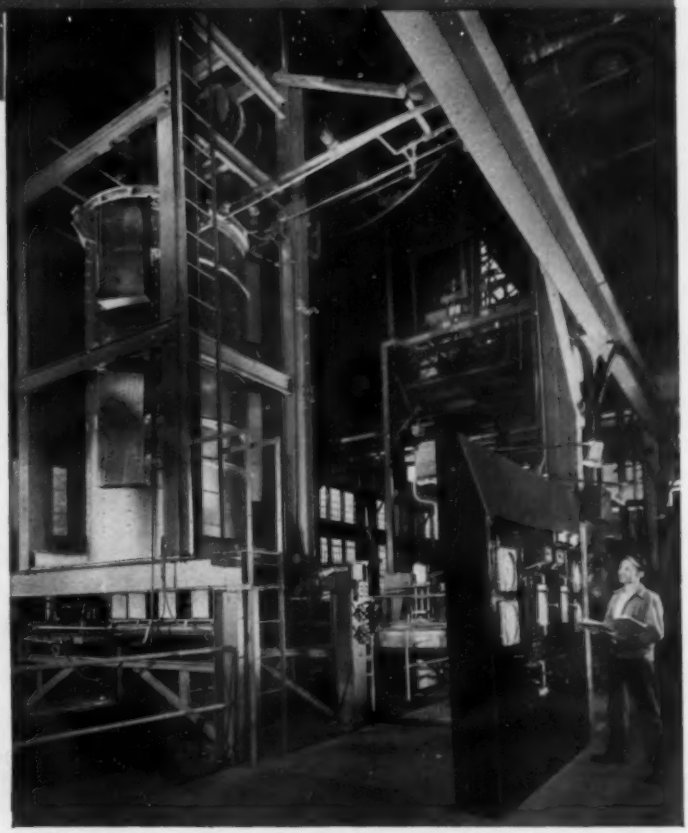

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The unusual design combines a stationary furnace beneath which quench tanks (oil or water) are moved and into which heated parts are lowered.

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Case No. 107

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Bright annealed steel is produced by Harris Steel Company, Kearny, New Jersey, with the help of two Kemp Model 6-MR Atmos Gas Producers. These two Kemp Generators burn city gas, to supply twelve furnace bases with purified controlled atmosphere.

Treating gas 24 hours a day, seven days a week, each Kemp unit produces 6,000 cfh of gas . . . enough to meet the needs of annealing 4,000 to 5,000 tons of steel per month.

User Reports Complete Satisfaction

Mr. Harry Vane, Plant Superintendent, reports "These Kemp units have been in constant service for 4 years without a bit of trouble. The only maintenance needed has been ordinary routine. Because of the constant purity and qualitative analysis of the gas the Kemp Generators produce, we have been able to secure constant control of color, temper and quality of our output."

Kemp Can Help You, Too

If efficient, carefully-controlled supply of protective atmosphere gas can help you solve production problems, it will pay you to call in a Kemp Engineer for a detailed discussion of your needs. No obligation, of course.

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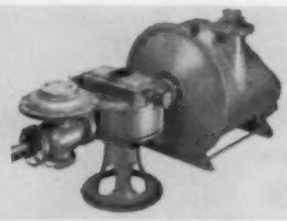
This Kemp industrial carburetor—the heart of every Kemp installation—assures the desired analysis of protective atmosphere gas under any demand without waste . . . without frequent adjustments.



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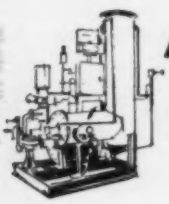

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1067. Heating Elements
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16-page bulletin on design, foundry practice and applications. *Electro-Alloys Div.*

1070. High-Alloy Castings
16-page bulletin, No. 3354-G, gives engineering data concerning castings used for resisting high temperatures, corrosion and abrasion. *Duraloy Co.*

1071. High-Strength Steel
66-page catalog on Mayari*R steel. Applications which take advantage of its wear and corrosion resistance. *Bethlehem Steel*

1072. High-Strength Steel
Data on low alloy steel. Chemical analysis, physical properties. *Youngstown Sheet & Tube*

1073. High-Temperature Alloys
"Haynes Alloys for High-Temperature Service" summarizes all available data on 10 superalloys and lists physical and mechanical properties of two newly developed alloys. *Haynes Stellite*

1074. High-Temperature Tubing
Bulletins ASL 285 and 286 on low-nickel seamless tubing and 25-12 austenitic steel for high temperature and corrosion service. *Babcock and Wilcox*

1075. Identifying Stainless
Cardboard chart outlining systematic method for rapid identification of unknown or mixed stocks of stainless steels. *Carpenter Steel*

1076. Indicators
New data sheet ND46-33 (23) on electronic potentiometer instruments for temperature indication. *Leeds & Northrup Co.*

1077. Induction Hardening
Bulletin M-1938 on induction hardening machine gives advantages and application of system. *Cincinnati Milling Machine*

1078. Induction Heating
New 36-page bulletin on high-frequency induction heating unit for brazing, hardening, soldering, annealing, melting and bombarding. *Lepel*

1079. Induction Heating
12-page booklet B-6519 on equipment for induction heating for forging, hardening, annealing and metal joining. *Westinghouse Electric*

1080. Induction Heating
60-page catalog tells of reduced costs and increased speed of production on hardening, brazing, annealing, forging or melting jobs. *Ohio Crankshaft*

1081. Induction Heating
Folder 15C8053A gives advantages of induction heating and specifications and dimensions of induction heater. *Allis-Chalmers*

1082. Induction Melting
Bulletin 70 on furnace. Controls, designs. *Inductotherm Corp.*

1083. Industrial Equipment
12-page catalog on finishing systems, cleaning, pickling, rustproofing equipment, ovens, conveying equipment. *R. C. Mahon Co.*

1084. Industrial Opportunities
74-page brochure on facts about Puerto Rico of interest to the manufacturer. *Economic Development Administration, Puerto Rico*

1085. Insulators
Bulletin P1-55 on insulators and insulating tubing. *McDanel Refractory Porcelain*

1086. Joining Magnesium
126-page book on welding, adhesive bonding and mechanical joining of magnesium. *Dow Chemical*

1087. Lab Test Dies
Complete information on multi-motion laboratory test specimen dies. *Haller, Inc.*

1088. Laboratory Furnace
Bulletin RT-10 on 25 lb. per hr. laboratory metal treating unit for carburizing, hardening, carbonitriding, brazing, carbon restoration. *Ipsen*

1089. Laboratory Mill
4-page reprint on rolling mill for laboratory studies, which may be operated as a 2-high, 3-high or 4-high mill. *Fenn Mfg.*

1090. Leaded Steel
8-page bulletin gives chemical composition, mechanical properties and case studies showing machining production rates of Ledloy, lead bearing steel. *Ryerson*

1091. Lubricant
8-page folder describes use of molybdenum disulfide lubricant in cold forming, cold heading and other applications. Case histories. *Alpha Molykote Corp.*

1092. Machinery
New booklet on how to buy a used machine tool. Written in question and answer form. *S & S Machinery Co.*

1093. Machining Stainless
16-page booklet on drilling, tapping, thread chasing, turning, milling, broaching. Machinability rating of stainless steels. *Crucible Steel Co.*

1094. Magnesium Alloys
Loose-leaf folder of data and tables on

STRAITS TIN REPORT

New developments in the production, marketing and uses of tin

MALAYAN TIN BUREAU

World consumption of tin in 1955 rose to 154,000 long tons, the greatest total since 1941. Third-quarter figures for 1956 indicate a consumption level of about 157,000 long tons. Indications point to a modest excess of production over consumption early in 1957.

★ ★ ★

Four of the six major tin-producing countries—Malaya, the Belgian Congo, Thailand and Nigeria — will probably maintain or increase their output in 1957. Significantly, Malaya alone has mined enough tin in each of the last six years to satisfy all U. S. industrial requirements. And an official of the Department of Mines in Kuala Lumpur recently stated that there is as much tin unmined in Malaya as has been taken out in the entire past.

★ ★ ★

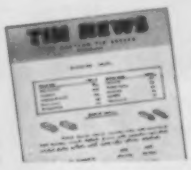
Approximately 9000 tons a year of colored ceramics are produced in this country. When tin oxide is used as an opacifier, four pounds are required for every pound of ceramics. When other materials are used as opacifiers, eight pounds are needed.

★ ★ ★

A new composite metal consisting of tin on nickel was recently developed. It is now being used in transistors in strips 0.1875 in. wide, 0.011 in. thick.

★ ★ ★

Tin is becoming progressively—and in some cases spectacularly—more useful in aeronautics. Tin cans and wind tunnels would appear to have little in common. Yet 8 million new tin cans (that's 135 boxcar loads) are now being used for temperature control in a $5 million trisonic wind tunnel in which jet planes and guided missiles will be tested.

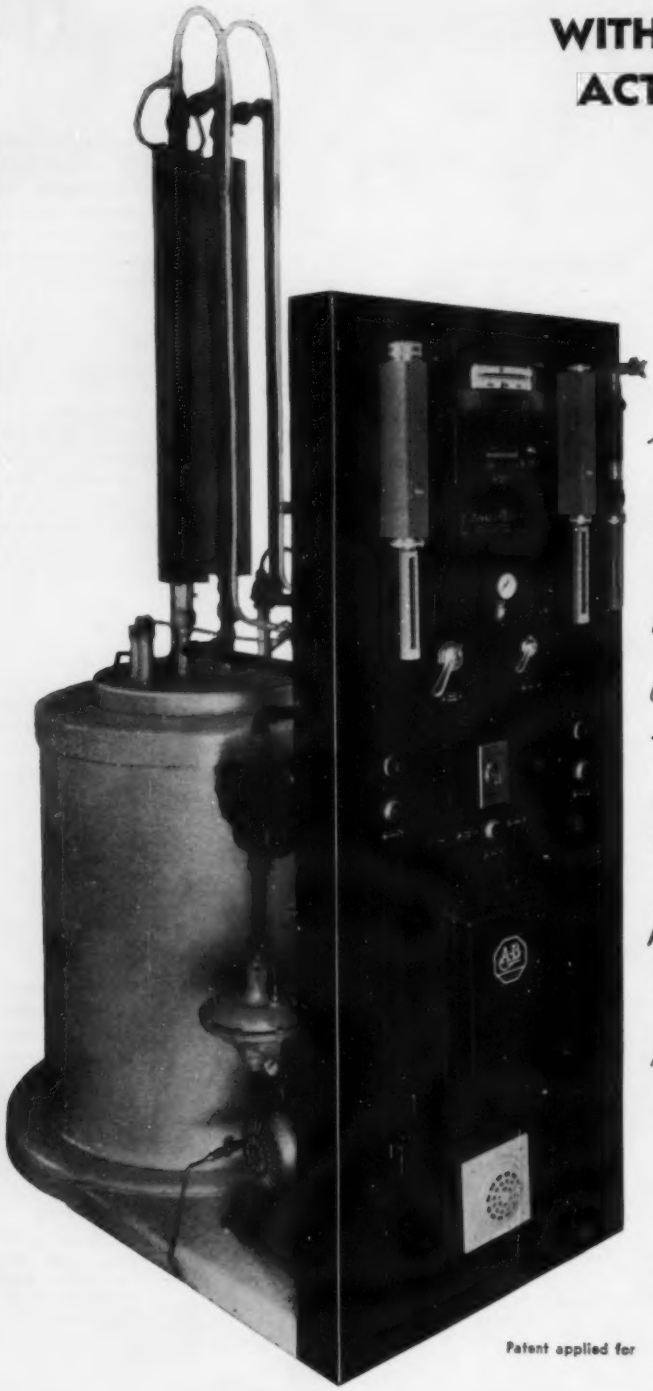


Ask us to send you TIN NEWS, a monthly letter. It will keep you posted on tin supply, prices, new uses and applications.

The Malayan Tin Bureau
Dept. 25D, 1028 Connecticut Ave., Washington 6, D.C.

REVERSIBLE ENDOTHERMIC GAS GENERATOR

WITH SELF CLEANING ACTION



Patent applied for

This generator really works—Responds to change in dew point from 70° to 0° in less than a minute. The reversals of gas flow keep this generator free from soot and therefore it requires practically no maintenance.
Connecticut Metal Treating Co.
Victor Kappel

Connecticut Gas Atmospheres

207 Knowlton St.
Bridgeport, Conn.

chemical specifications, properties, extrusion, machining operations. *Brooks and Perkins*

1095. Magnesium Specs
Bulletin DM12n on specifications of government agencies, AMS, SAE, ASTM. *Dow Chemical*

1096. Malleable Iron
20-page booklet on how malleable iron is made. *Albion Malleable Iron Co.*

1097. Marking Machines
Data on various types of marking machines from bench mounted machines for light duty marking to machines capable of marking at up to 6 tons table pressure. *Jas. H. Matthews & Co.*

1098. Master Alloys
24-page pocket bulletin on high alloy materials also includes metric equivalents tables, element melting points, temperature conversion tables. *Alloy Metal Products, Inc.*

1099. Mechanical Cleaning
Folder on wire brushes for metal cleaning. Brush specifications and characteristics. *Osborn Mfg. Co.*

1100. Melting Furnace
Bulletin gives specifications, diagrams, performance and other technical data on Simplex melting furnaces. *Lindberg Engineering*

1101. Melting Furnaces
28-page catalog on Heroult electric melting furnaces. Types, sizes, capacities, ratings. *American Bridge*

1102. Melting Furnaces
48-page book 9A on line of standard furnaces from research to 200-ton steel mill types. *Pittsburgh Lectromelt*

1103. Metal Analysis
Brochure on Quantometer, which furnishes pen-and-ink records of quantitative spectrochemical analyses with extra copies. *Applied Research Labs.*

1104. Metal Cleaning Equipment
Folder gives data on metal cleaners for use with water in still-tank or spray-washing equipment. *Solventol*

1105. Microhardness Tester
Bulletin describes the Kentron microhardness tester. *Torsion Balance Co.*

1106. Microhardness Tester
Data on combination microhardness tester and metallurgical microscope. *Sheffield Corp.*

1107. Microscopes
Catalog on metallograph and several models of microscopes. *United Scientific*

1108. Mo-Fe Castings
Bulletins 1 and 2 on molybdenum iron castings give advantages of molybdenum in these castings. *Climax Molybdenum*

1109. Moisture Measurement
12-page bulletin on how to measure water vapor in air and other gases. Gravometric, dew point and wet and dry bulb methods, and others. *Pittsburgh Lectrodryer*

1110. Molybdenum
24-page booklet gives physical and chemical property data on molybdenum powders, wire, alloys. *Sylvania Electric*

1111. Nondestructive Testing
8-page bulletin on equipment for nondestructive testing of bars, rods, tubing. *Magnetic Analysis*

1112. Nonferrous Melting
Bulletin 26-A on high-frequency furnaces for melting copper, silver, gold, platinum, aluminum and magnesium. *Ajax Electrothermic*

1113. Nonferrous Wire
Folder gives wire gage and footage chart and data on beryllium copper, phosphor bronze, nickel, silver, brass and aluminum wire. *Little Falls Alloys*

1114. Oil Quenching
8-page brochure tells in detail how carbon steel often can replace alloy steel when additive is used in the quenching oil. *Aldridge Industrial Oils*

1115. Optical Instruments
Ways to use optical instruments in manufacturing and inspection. Magnifiers, microscopes, wide field tubes, macroscopes and comparators discussed. *Bausch & Lomb Optical*

1116. Ovens
16-page bulletin No. 53 on various types of core and mold ovens, special ovens and heat treating furnaces. *Carl-Mayer*

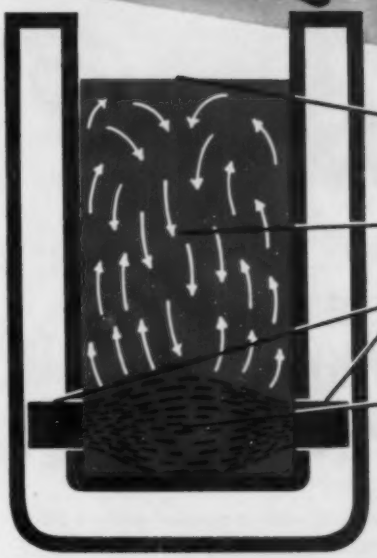
1117. Permanent Magnets
New 12-page booklet on permanent magnets, Thermistors and Thyrite varistors tells how they can be used in design of electrical equipment. *Metallurgical Products Dept., General Electric Co.*

1118. Phosphor Bronze
Publication B-38 gives properties, chemistry, forms of 11 analyses of phosphor bronze. *American Brass Co.*

1119. Pickling Baskets
12-page bulletin on mechanical picklers, crates, baskets, chain and accessories. *Youngstown Welding & Eng'g*

1120. Pickling Baskets
Data on baskets for degreasing, pickling, anodizing and plating. *Jelliff*

Making Sense . . .



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It has no equal in general cleaning. Unexcelled for shot peening and sheet or plate descaling.

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Butler, Pa.
Subsidiary of Pittsburgh Crushed Steel Co.
Pittsburgh 1, Pa.

1121. Plating
New data and specification sheet covering tin plating a wide range of nonferrous thin strip metals. *Somers Brass Co.*

1122. Plating Solutions
Operating manuals for plating with metal fluoborate solutions. *Baker & Adamson.* See page 63

1123. Post-Weld Heat Treatment
8-page bulletin TR-543 demonstrates the need for post-weld heat treatment of air hardening alloys. *Babcock & Wilcox*

1124. Powdered Metals
Booklet on design, properties, production and application of brass and other nonferrous powder parts. 24 case histories. *New Jersey Zinc*

1125. Powdered Metals
12-page brochure describes and illustrates process of making parts; assembly and finishing operations. Case histories. *Powdered Metal Parts Div., Lux Clock Mfg. Co.*

1126. Precision Casting
8-page bulletin on investment castings of various ferrous and nonferrous alloys. *Engineered Precision Casting*

1127. Precision Castings
16-page booklet includes composition and properties of carbon, low alloy, stainless, high temperature and tool steel precision castings. *Crucible Steel*

1128. Press Brakes
New 4-page bulletin No. 57PR on heavy duty steel press brakes. Principal features, specifications and capacities of 40 standard sizes. *Dreis & Krump Mfg. Co.*

1129. Presses
8-page bulletin on new straight side crank-type press. Standard specifications. *Hamilton Div., Baldwin-Lima-Hamilton Corp.*

1130. Presses
Data on mechanical and hydraulic powered metal presses 8 to 500-ton capacities. *Haller, Inc.*

1131. Product File
30 new products and 500 pieces of literature described in 20-page reprint of items appearing in monthly magazine during first quarter, 1957. *Metal Progress*

1132. Pyrometer Calibration
"Pyrometer Thermocouple Calibration Data" includes tables of data released by National Bureau of Standards. *Bristol Co.*

1133. Pyrometers
12-page Bulletin 713 on indicating and controlling pyrometers. Functional diagrams of installations. *General Electric*

1134. Quench Agitation
32-page booklet on 1 to 500 hp. mixers, construction, operation, applications. *Mixing Equipment Co.*

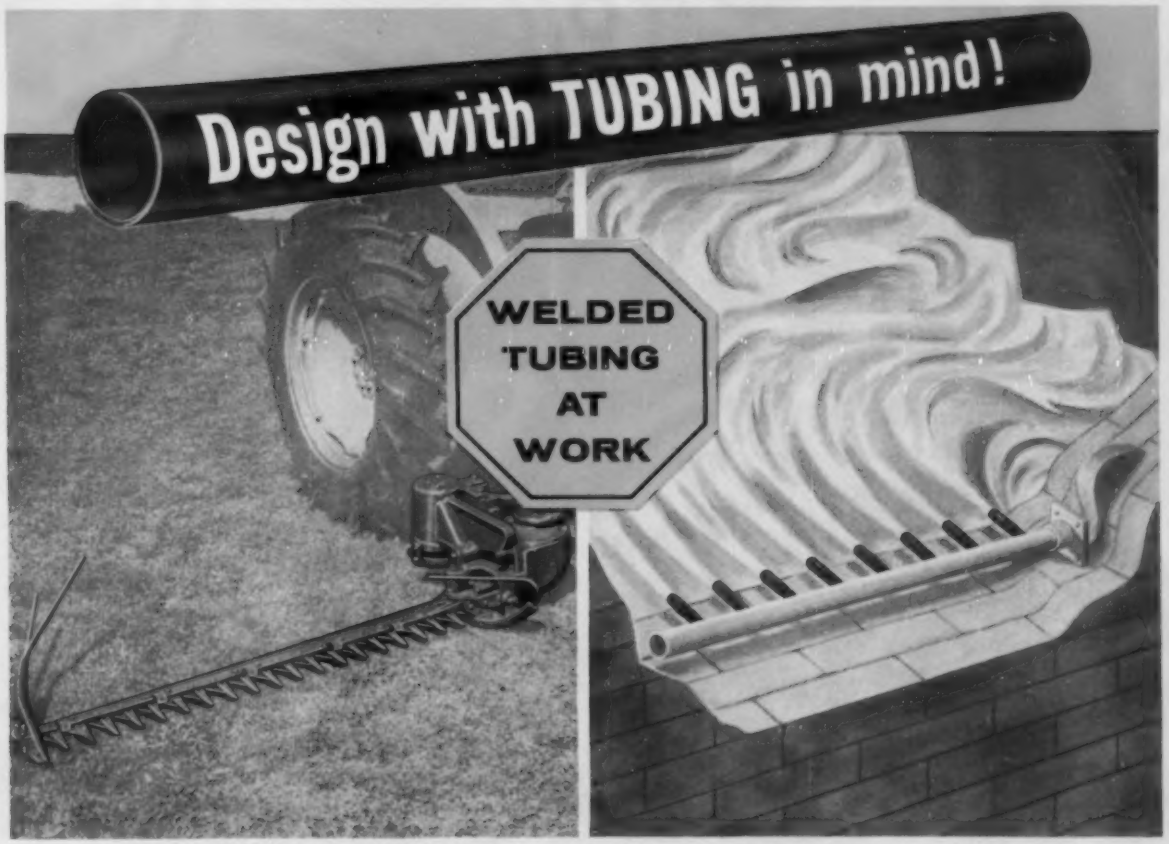
1135. Quenching
Heat Treat Review, Vol. 7, No. 3, contains a discussion of quenching media, temperature ranges. *Surface Combustion*

1136. Quenching
16-page booklet on modified and full marquenching procedures. Hardness and dimensional control data, cooling curves, case histories. *Sinclair Refining Co.*

1137. Quenching
Bulletin 120 on use of heat exchangers to provide heat control in quenching bath. *Niagara Blower*

1138. Quenching Oil
New Bulletin 45 on quenching oil treats mechanism of quenching and explains how Sunquench 78 aids. *Sun Oil*

(*Continued on* 48-A)



Weight-saving Welded Carbon Steel Tubing provides strength and resistance to stresses in all directions in nine mechanical functions of this cutter bar attachment. If it moves, use Welded Steel Tubing.

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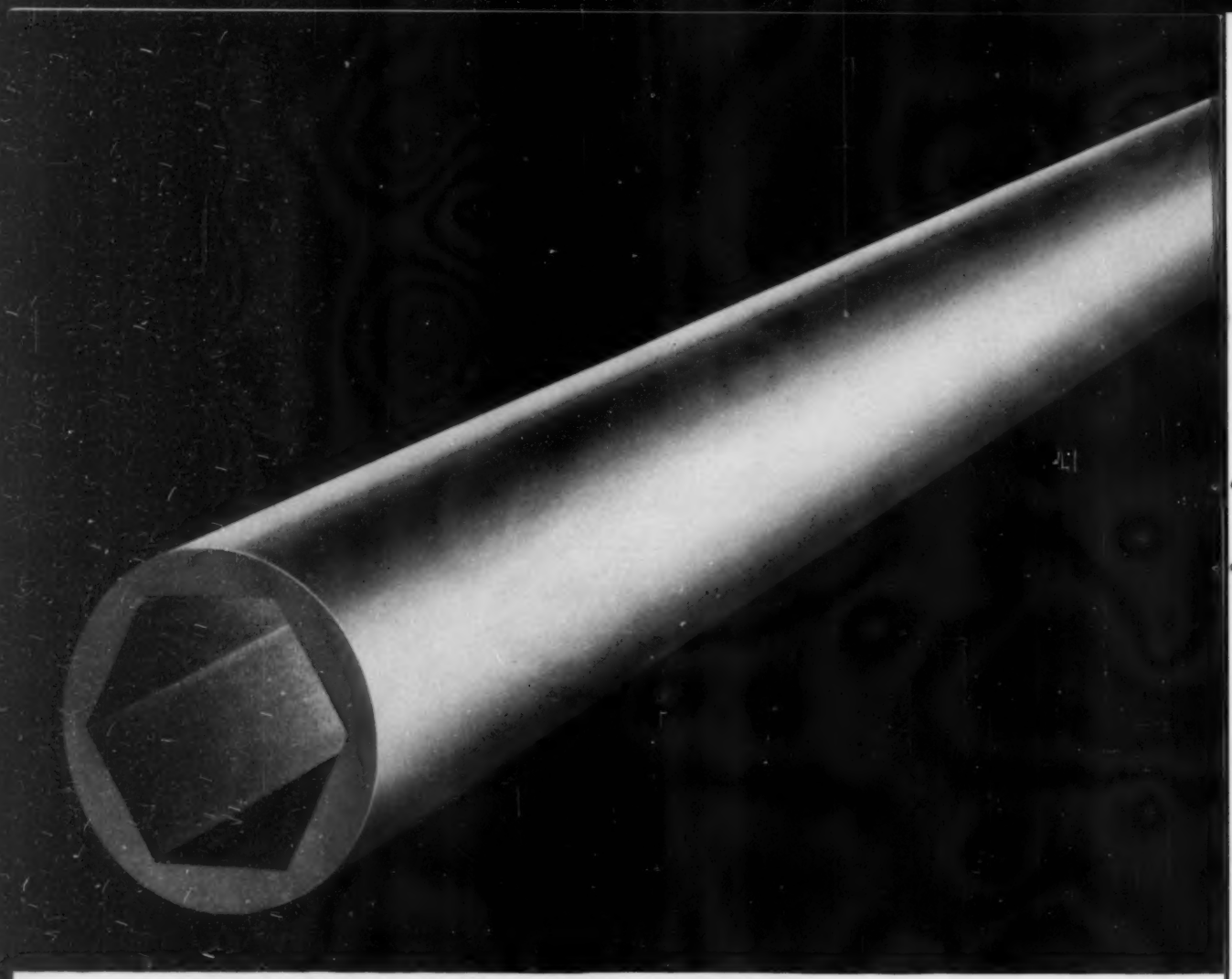

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—in stainless steel, with each part 22 inches long, the outside diameter a shade over 2 inches and with tolerances of +.000" to —.010" across the flats?

On jobs like this, there's possible trouble ahead if you start with solid stock, or even round heavy wall tubing. Machining problems, surface finishing, scrap loss, special cutting oils or compounds—added to the original stock cost may make the final cost of the part prohibitive.

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Before you start your next production run, call Mr. Tubes at your nearby B&W Tubular Products Division District Sales Office—let him match tubing steels, types, finishes, shapes and tolerances to your applications—he will show you how to keep final costs low. Or write for bulletins 361 and 340. The Babcock & Wilcox Company, Tubular Products Division, Beaver Falls, Pa.

TA-6086-M2

Seamless and welded tubular products, seamless welded fittings and forged steel flanges—in carbon, alloy and stainless steels.

(Continued from page 46)

1139. Radiation Badges
Data on badges which record exposures to radiation. *Picker X-Ray Corp.*

1140. Radioactive Chemicals
24-page booklet describes radioactive chemicals and their uses. Lists those available. *Baker & Adamson*

1141. Rare Earths
8-page Progress Report Number 1, "Rare Earths in Iron and Steel Melting". *Molybdenum Corp.*

1142. Rare Earths
12-page handbook on rare earth chemicals, thorium. Applications of rare earths. *Heavy Minerals Co.*

1143. Recirculating Furnace
Bulletin on continuous-type recirculating furnace shows design of furnace, its operation and advantages. *Industrial Heating Equipment*

1144. Refractories
40-page book lists super-refractories for heat treating furnaces and gives data on use in different kinds of furnaces. *Refractories Div., Carborundum*

1145. Refractories
8-page catalog of super refractory shapes, tubes, insulators for use to 3000° F. *Morganite*

1146. Refractory Cement
Bulletin discusses refractories and heat-resistant concrete. *Lumnite Div.*

1147. Refrigerated Bath
Bulletin on refrigerated baths, visible and constant temperature models. Construction, applications. *Wilkens-Anderson*

1148. Resistance Welding
24-page catalog on equipment for resistance welding includes reference tables and property and application charts. *Ampco*

1149. Rust Preventives
12-page bulletin on water-soluble rust preventive. *Production Specialties*

1150. Salt Bath Equipment
8-page bulletin on Kolene descaling, desanding, and graphite removal processes. *Kolene Corp.*

1151. Salt Bath Furnaces
Reprint No. 145 on basic principles of electrode type salt bath furnaces gives methods of mechanization and applications. *Ajax Electric*

1152. Salt Bath Furnaces
Data on salt bath furnaces for batch and conveyorized work. *Upton*

1153. Salt Baths
32-page bulletin on salts for tempering, annealing, neutral hardening, martempering and carburizing. Heat treating data. *E. F. Houghton*

1154. Sand Blasting
New 4-page bulletin 1256 on sand blasting machines for cleaning, deburring, surface preparation. *Leiman Bros.*

1155. Sand Control
32-page book on defects and troubles in foundry and how to remedy them through sand control. *Claud S. Gordon*

1156. Sawing
Data on bandsawing and bandfiling machine. Speeds, description of machine. *S & S Machinery Co.*

1157. Saws
Catalog C-55 describes 35 models of metal-cutting saws. *Armstrong-Blum*

1158. Shear
Bulletin on bar and billet shear for rounds, squares, flats, billets and structurals, either hot or cold. *Hill Acme Co.*

1159. Shot
Complete catalog on abrasive shot and grit. SAE specifications. Cleaning and peening methods. *Abrasive Shot & Grit*

1160. Shotblasting
16-page "Primer on the Use of Shot and Grit". Problems of blast cleaning operations. *Hickman, Williams*

1161. Slug Caster
Data on automatic slug caster for producing aluminum slugs for forging and impact extrusion. *Stroman Furnace*

1162. Solvent Cleaning
16-page booklet on how to use solvent detergents for removing carbon, grease, dirt, paint. *Oakite Products*

1163. Sodium
28-page booklet on using sodium in dispersed form tells how dispersions are prepared and handled, and their advantages. *Ethyl Corp.*

1164. Spectrograph
Feature article in Jaco News Letter, February 1957, on 6.8 meter grazing incidence vacuum spectrograph. *Jarrell-Ash Co.*

1165. Stainless Castings
Bulletin on use of stainless castings in fruit juice processing equipment. *Alloy Casting Institute*

1166. Stainless Steel
12-page booklet on precipitation hardening stainless steel. Mechanical properties after various heat treatments. *Electric Steel Corp.*

1167. Stainless Steel
12-page bulletin on chromium-manganese austenitic steel. Effect of cold working, properties at elevated temperatures, corrosion resistance, magnetic permeability. *U.S. Steel Corp.*

1168. Stainless Steel
44-page book gives detailed information on use of stainless steel in the chemical industries. *Crucible Steel*

1169. Stainless Steel
Booklet on 430 stainless. Properties, fabrication. *Sharon Steel*

1170. Stainless Strip
32-page brochure on 20 types of stainless strip steel. Recommended applications, chemical, physical and mechanical properties, corrosion resistance. *Superior Steel Corp.*

1171. Steel 52100
Data sheet on high-purity 52100 steel, made by vacuum melting. *Vacuum Metals*

1172. Steel Castings
Bulletins on high and low carbon steel casting specifications. Allied specifications. *Unitcast Corp.*

1173. Steel Powders
Data sheet on stainless and alloy steel prealloyed steel powders. *Vanadium-Alloys Steel Corp.*

1174. Steel Tubing
48-page Handbook F-3 on fabricating and forging steel tubing. Bending, shaping, cutting and joining operations described. *Ohio Seamless Tube*

1175. Stereomicroscopes
38-page catalog D-15 shows value of three-dimensional microscopes for industrial assembly lines and research laboratories. *Bausch & Lomb Optical*

1176. Test Bars
18-page bulletin No. 168 on design of test bar patterns, production of test bars, testing procedures. *Federated Metals Div., American Smelting and Refining*

1177. Test Specimens
Data on machine for cutting test specimens to ASTM specifications. *Sieburg Industries*

1178. Testing Instruments
16-page bulletin on portable recorders, voltmeters and ammeters, surface roughness scales and other electric testers. *General Electric*

1179. Textured Metal
16-page booklet on advantages and

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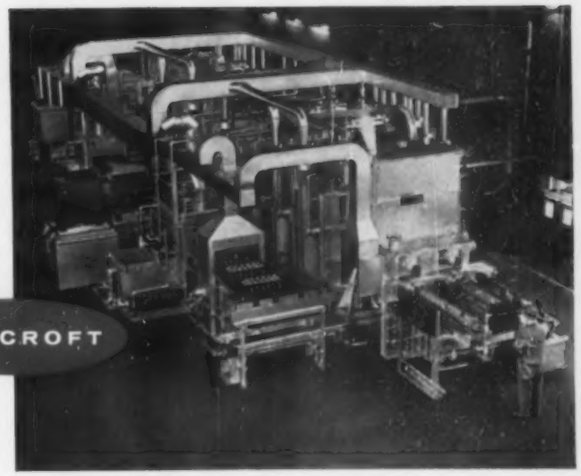


LET'S TALK

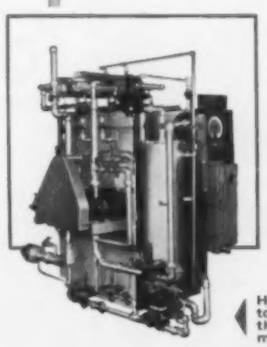
CONTROLLED ATMOSPHERES

Holcroft has pegged many of its research activities to the problems of controlled atmosphere heat treating. As a result, Holcroft has blazed the trail for industry.

Controlled atmospheres protect the stock while it is being treated and help produce the desired finish to the parts. Scale and decarburization are eliminated. Stock in the furnace chamber is surrounded by a gas atmosphere which excludes all air and products of combustion.

Basic gas generator patents go back to 1883. However, the first real use and understanding of fundamental equilibrium constants—now in general use in all gas atmosphere work—was by Holcroft in 1934. Dew point cups and equilibrium curves were furnished customers at that time. Today, Holcroft's new Lo-Dew generator (750, 1200 and 2400 cfh) provides *rated capacities* at low dew points.

Advances like these are typical of the scope of Holcroft activities—proof that you can get right answers without prejudice. Insist upon a Holcroft quotation as your first step when you have a heat treat problem. *You'll save!*



Holcroft's new gas generator designed to produce gas atmospheres between the limits of perfect combustion and modified "302".

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New Series 8000 Multi-point Recorders Feature Easy Reading, Operation, and Service

Swing-out design making all components readily accessible in Series 8000 multi-point recorder is demonstrated below. Cover of recorder mechanism removed to show construction.

Permanent recording of as many as 16 points on one chart — at standard recording speeds ranging from 3 to 24 inches per hour — is readily obtained on Wheelco Series 8000 multi-point recorders. Thermocouples, radiation detectors, and other sensing devices that resolve the measured variable into an electrical signal all work equally well with the new recorders.

Additional features include: up to six limit switches for high and/or low signal indication, single or multi-color printing, and fast cross-chart speed. Call your nearby Wheelco field engineer today for Bulletin F-7955, or to discuss how these multi-point recorders can improve your processing.

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applications of textured metal. *Rigidized Metals*

1180. Thermocouple Alloys

20-page booklet on chromel-alumel alloys gives sizes, temperature-millivolt equivalents, standards, applications. *Hoskins Mfg.*

1181. Thermocouples

36-page Bulletin 19-10 describes various types of thermocouples, extension wire and other accessories. *Foxboro*

1182. Thermocouples

14-page bulletin No. 5 on miniature protected thermocouples. Calibrations and temperature ranges available, immersion lengths and other data. *Thermo Electric*

1183. Thickness Control

New 12-page booklet on systems for automatic control of strip thickness of ferrous and nonferrous cold mills and of coatings. *Industrial Nucleonics Corp.*

1184. Thickness Gage

Folder on pocket-size gage. How to use it. *Ferro Corp.*

1185. Thickness Tester

Data sheets give ranges, principle of operation of nondestructive thickness tester. *Unit Process Assemblies*

1186. Tin News

Interesting monthly report covers important current developments in the production, marketing and use of tin. *Malayan Tin Bureau*

1187. Titanium Alloy

Data sheet on MST 6A1-4V high temperature titanium alloy. Creep and fatigue properties. *Mallory-Sharon Titanium Corp.*

1188. Titanium and Zirconium

16-page bulletin, "The Hydrimet Process", on titanium and zirconium metals and hydrides, and other metallurgical hydrides. *Metal Hydrides*

1189. Tool Steel

Fourth edition of the 204-page handbook. Types, properties and applications of tool steels. Selection, tool steel products, working tool and high speed steels. *Allegheny Ludlum Steel Corp.*

1190. Tool Steel

4-page bulletin on Ry-alloy, oil-hardening tool steel. Applications, advantages, heat treatment and forging practice. *J. T. Ryerson & Son*

1191. Tool Steel

44-page stock list is indexed and includes sizes, weights, and analyses. Decimal conversion and hardness conversion tables. *Uddeholm*

1192. Tool Steel Heat Treat

Bulletin 1147EE on electric furnace for heat treatment of high speed tool steel. *Hevi Duty*

1193. Tubing

Data card 146-A on Croloy 5 pipe, tubing and welding fittings. Elevated temperature properties, properties developed by heat treatment. *Babcock & Wilcox*

1194. Tubing

Memorandum No. 2 on Weldrawn tubing fabricated from cold-rolled strip, fusion welding the edges and cold drawing to size. *Superior Tube*

1195. Tubing Materials

Data on limestone chips, red granite chips, aluminum oxide, special honing, burnishing, abrasive compounds. *Universal Tumbling Supply*

1196. Tungsten

New 12-page booklet on tungsten coil products for electronic and lighting applications. *Sylvania Electric Products, Inc., Tungsten and Chemical Div.*

1197. Ultrasonic Testing

6-page folder on immerscope diagrams instrument and tells how it may be used. *Curtiss-Wright Corp.*

1198. Ultrasonics

Data sheet on gages for thickness measurement, coating measurement, inspection. *Branson Instruments*

1199. Vacuum Furnaces

8-page bulletin 552 on high vacuum furnaces. Equipment and methods for vacuum melting. Vacuum treating—annealing, heat treating, degassing, brazing, sintering. *High Vacuum Equipment Corp.*

1200. Vacuum Melting

8-page bulletin on production and testing equipment for vacuum melting. Advantage. *Utica Metals Div., Utica Drop Forge & Tool*

1201. Vacuum Metallizing

Bulletin 780 gives uses and advantages of vacuum metallizing, materials and properties of vacuum metallized coatings, the process, equipment. *Stokes*

1202. Vacuum Pumps

16-page catalog on rotary positive air and vacuum pumps. Dimensions, capacities, performance curves. *Leiman Bros.*

1203. Vacuum Pumps

New 28-page catalog No. 752 contains specifications, tables of formulas, constants and conversion factors. Maintenance procedures. *F. J. Stokes*

1204. Vacuum-Melted Metals

Data on alloys available and their physical properties. *Carboloy Dept., General Electric*

1205. Vanadium in Steel

189-page book on properties of ferrous alloys containing vanadium and their applications. *Vanadium Corp.*

1206. Welding

New technical data card 162A on welding stainless tubing and pipe gives information on welding characteristics of austenitic and ferritic types, methods and techniques. *Babcock & Wilcox*

1207. Welding

7-page reprint on properties of weld deposits of nickel-molybdenum-vanadium steel. *International Nickel Co.*

1208. Welding

Three bulletins on Fillerarc consumable-electrode, gas-shielded welding process. *General Electric*

1209. Welding Chart

Wall chart gives instructions on use of electrodes, proper welding procedure, types of joints, standard steel shapes. *Hobart Brothers Co.*

1210. Welding Electrodes

84-page pocket-size booklet describes characteristics, coating, sizes of various electrodes and compares them with standard designations and other electrode brand names. *Harnischfeger*

1211. Welding Equipment

Catalog on Cadweld process and arc-welding accessories. *Erico Products*

1212. Wire

New 120-page handbook lists 100 types of steel wire. Size ranges, weights, tensile strength and chemical composition for each type. 16 pages of tables and hardness conversion chart. *Pittsburgh Steel Co.*

1213. Wire Mesh Belts

130-page manual on conveyor design, belt specifications, metallurgical data. *Cambridge Wire Cloth*

1214. X-Ray Diffraction

New 4-page bulletin on X-ray diffraction for research, production control. Two units described. *General Electric, X-Ray Dept.*

1215. X-Ray Supplies

Bulletin on X-ray films and chemicals for radiography. *Ansco*

1216. Zirconium

Vol. 1, No. 1, More Zr Facts, describes zirconium production processes. *Carborundum Metals Co.*

April, 1957

894	920	946	972	998	1024	1050	1076	1102	1128	1154	1180	1206
895	921	947	973	999	1025	1051	1077	1103	1129	1155	1181	1207
896	922	948	974	1000	1026	1052	1078	1104	1130	1156	1182	1208
897	923	949	975	1001	1027	1053	1079	1105	1131	1157	1183	1209
898	924	950	976	1002	1028	1054	1080	1106	1132	1158	1184	1210
899	925	951	977	1003	1029	1055	1081	1107	1133	1159	1185	1211
900	926	952	978	1004	1030	1056	1082	1108	1134	1160	1186	1212
901	927	953	979	1005	1031	1057	1083	1109	1135	1161	1187	1213
902	928	954	980	1006	1032	1058	1084	1110	1136	1162	1188	1214
903	929	955	981	1007	1033	1059	1085	1111	1137	1163	1189	1215
904	930	956	982	1008	1034	1060	1086	1112	1138	1164	1190	1216
905	931	957	983	1009	1035	1061	1087	1113	1139	1165	1191	
906	932	958	984	1010	1036	1062	1088	1114	1140	1166	1192	
907	933	959	985	1011	1037	1063	1089	1115	1141	1167	1193	
908	934	960	986	1012	1038	1064	1090	1116	1142	1168	1194	
909	935	961	987	1013	1039	1065	1091	1117	1143	1169	1195	
910	936	962	988	1014	1040	1066	1092	1118	1144	1170	1196	
911	937	963	989	1015	1041	1067	1093	1119	1145	1171	1197	
912	938	964	990	1016	1042	1068	1094	1120	1146	1172	1198	
913	939	965	991	1017	1043	1069	1095	1121	1147	1173	1199	
914	940	966	992	1018	1044	1070	1096	1122	1148	1174	1200	
915	941	967	993	1019	1045	1071	1097	1123	1149	1175	1201	
916	942	968	994	1020	1046	1072	1098	1124	1150	1176	1202	
917	943	969	995	1021	1047	1073	1099	1125	1151	1177	1203	
918	944	970	996	1022	1048	1074	1100	1126	1152	1178	1204	
919	945	971	997	1023	1049	1075	1101	1127	1153	1179	1205	

METAL PROGRESS,

7301 Euclid Avenue, Cleveland 3, Ohio

Please have literature circled at the left sent to me.

Name _____

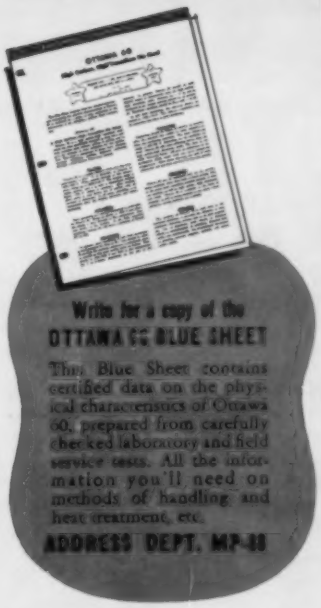
Title _____

Company _____

Address _____

City and State _____

Postcard must be mailed prior to July 1, 1957. Students should write direct to manufacturers.


Write for a copy of the
OTTAWA 60 BLUE SHEET
This Blue Sheet contains certified data on the physical characteristics of Ottawa 60, prepared from carefully checked laboratory and field service tests. All the information you'll need on methods of handling and heat treatment, etc.
ADDRESS DEPT. MP-88

OTTAWA 60 is a *new* die steel, an A-L "original," developed primarily to deep draw and form stainless steel. As intended, it performs without galling or pickup and shows exceptional wear resistance in that service. We have plenty of case histories to show you in proof.

But *wherever* you use Ottawa 60 draw dies—not just on stainless steel—this high-carbon, high-vanadium alloy comes through for you. Illustrated above are the first and second draws on transformer housings, produced from .037" gauge SAE 1010 strip. The company formerly used dies made of 5% chrome air-hardening die steel—and later a more highly alloyed material—without ever getting more than about 2000 pieces before the dies began to show gall marks and pickup, and parts were rejected due to scoring, breakage and oversize. *Dies made from Ottawa 60 forgings cured that! Results after 25,000 pieces showed no pickup and no wear on punch or die.*

● You can solve many a problem and save real money with Ottawa 60 draw dies! Write for information or call in our Field Service Staff to help you get started. ***Allegheny Ludlum Steel Corporation, Oliver Bulding, Pittsburgh 22, Pa.***

For complete **MODERN** Tooling, call

Allegheny Ludlum

WAD 8463

AL ® FINE TOOL STEELS SINCE 1854

A Boeing B-47 Stratojet medium bomber gets a take-off assist from 30 Phillips Petroleum Company M15 JATOs.

N-A-X HIGH-TENSILE is readily formed and welded. Here, before welding, a worker sizes the container's aft head, drawn by a 250-ton press. Bottom forging is locked in.

N-A-X HIGH-TENSILE STEEL FORMS AND WELDS READILY

Formability: Even at the higher strength levels (50% greater than mild carbon steel) this material can be cold formed and drawn into very difficult stampings and cold formed shapes.

Weldability: Its weldability by any process is excellent, maintaining toughness through a wide range of temperatures. Under-bead cracking tests are excellent. Using American Welding Society standard bead-weld testing, shows under-bead hardness rises only to 95 Rockwell from 80-85 Rockwell prior to welding.

Make *your* product better, too—
with this high-strength steel

How N-A-X® HIGH-TENSILE STEEL

supplied the money-saving answer to a critical take-off problem

JATO rockets boost heavily laden planes into the air faster, let them operate from shorter runways. A new JATO developed by Phillips Petroleum Company required a case that would endure a pressure of 1,000 pounds per square inch at the high blast temperatures. Yet it must be lightweight, easily fabricated, economical.

In 1954, 100 JATO cases of N-A-X HIGH-TENSILE steel were tested at Air Force Plant 66 near McGregor, Texas, where Phillips Petroleum is contractor-operator.

Result: The N-A-X HIGH-TENSILE case passed every test with flying colors. It *surpassed* the required standards for strength by as much as 20 percent.

The high-strength characteristics that make N-A-X HIGH-TENSILE a better steel for JATO fuel containers also make it better for many other types of pressure containers, where high strength and lighter weight are equally important. It is particularly suitable for Propane cylinders and pressure vessels for the chemical, automotive and oil industries, that must withstand severe interior pressures and handling abuses . . . and for such products as truck and trailer frames, wheels and bumpers, railroad and earth-moving equipment, shipping containers, pipe, and many others.

Other Important Advantages: N-A-X HIGH-TENSILE STEEL, compared with carbon steel, is 50% stronger • has high fatigue life with great toughness • is more stable against aging • is more resistant to atmospheric corrosion. It polishes to a high luster at minimum cost • has greater resistance to abrasion or wear • offers greater paint adhesion.

With N-A-X HIGH-TENSILE you can design longer life, strength with lightness, and economy into your products. Let us show you how.

COMPANION HIGH-STRENGTH STEEL IN THE N-A-X FAMILY

N-A-X FINEGRAIN. A low-alloy high-strength steel ideally suited for applications where the enhanced resistance to atmospheric corrosion of N-A-X HIGH-TENSILE is not required.

N·A·X
HIGH-TENSILE STEEL

N-A-X Alloy Division
GREAT LAKES STEEL CORPORATION
Detroit 29, Michigan — Division of
NATIONAL STEEL CORPORATION

N-A-X Alloy Div., Dept. E-1,
Great Lakes Steel Corp., Detroit 29, Mich.

☐ Please send me 8-page illustrated technical catalog on N-A-X HIGH-TENSILE Steel.

☐ Please have your representative contact me.

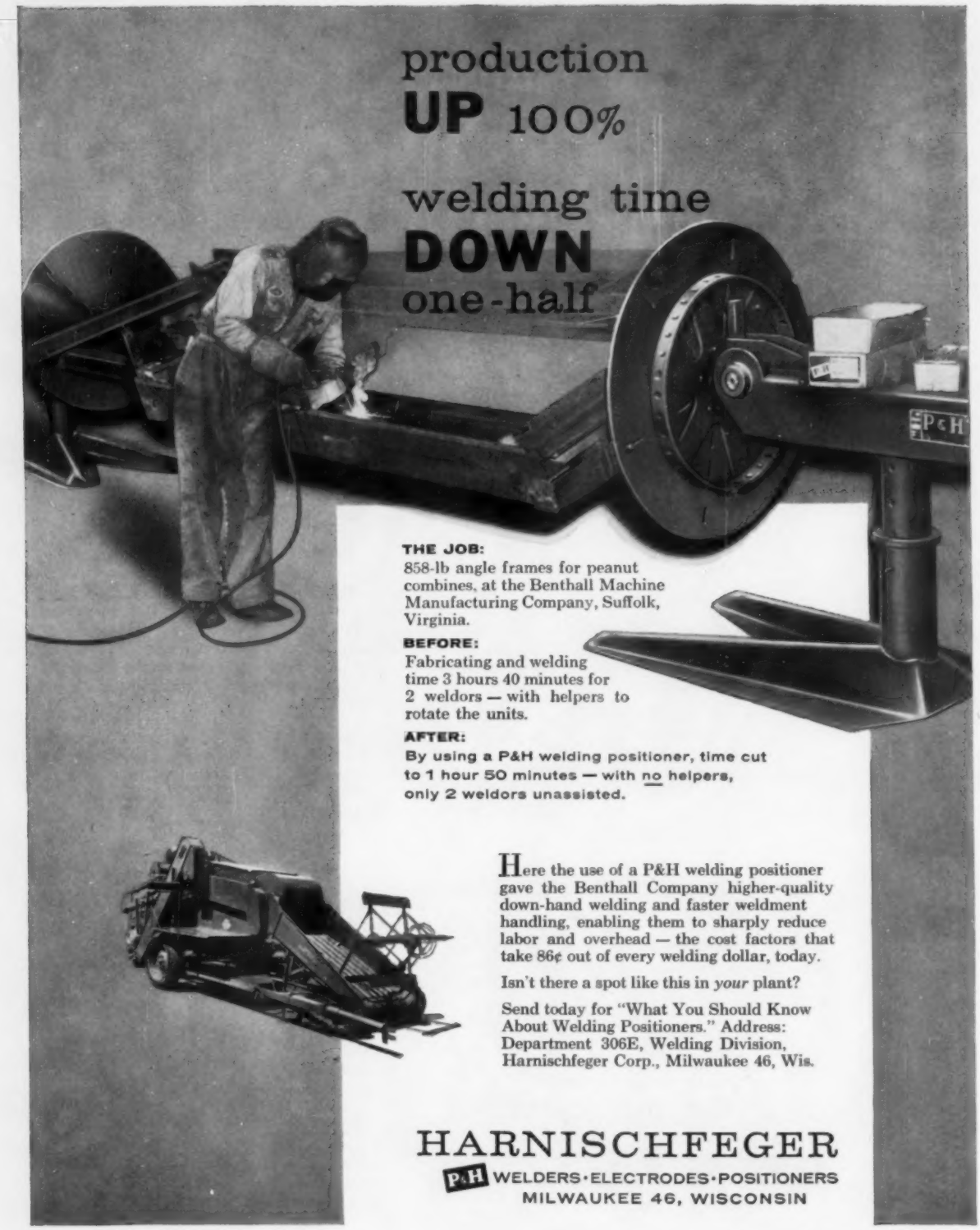
Name_____ Title_____

Company_____

Street_____

City_____ Zone_____ State_____

a before-and-after story about P&H welding positioners:



THE JOB:
858-lb angle frames for peanut combines, at the Benthall Machine Manufacturing Company, Suffolk, Virginia.

BEFORE:
Fabricating and welding time 3 hours 40 minutes for 2 weldors — with helpers to rotate the units.

AFTER:
By using a P&H welding positioner, time cut to 1 hour 50 minutes — with no helpers, only 2 weldors unassisted.

Here the use of a P&H welding positioner gave the Benthall Company higher-quality down-hand welding and faster weldment handling, enabling them to sharply reduce labor and overhead — the cost factors that take 86¢ out of every welding dollar, today.

Isn't there a spot like this in *your* plant?

Send today for "What You Should Know About Welding Positioners." Address: Department 306E, Welding Division, Harnischfeger Corp., Milwaukee 46, Wis.

HARNISCHFEGER
P&H WELDERS · ELECTRODES · POSITIONERS
MILWAUKEE 46, WISCONSIN

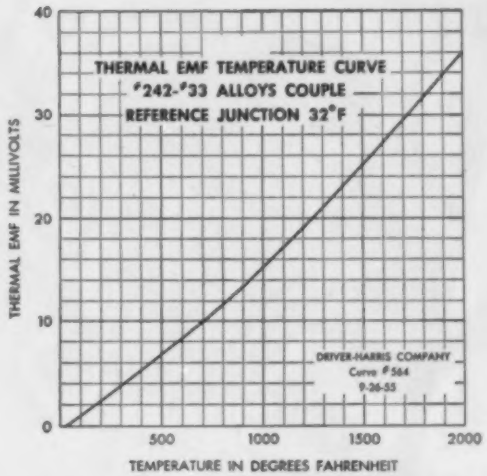
Driver-Harris Announces Major Advance in Pyrometry!

New #242-33 Thermocouple* for Reducing Atmospheres Maintains Calibration Through a Greatly Extended Life

This new Driver-Harris Thermocouple was developed primarily to withstand industrial reducing atmospheres at high temperatures and thereby to end the danger of runaway furnaces and ruined charges.

Unusually high resistance to "green-rot" attack is the outstanding property of the alloys of this thermocouple, whose analysis is:

Positive Leg (No. 242 Alloy)	Negative Leg (No. 33 Alloy)
80/20 Ni-Cr + Cb	3% Si-Ni



Although the thermal-emf response of this thermocouple is lower than the conventional thermocouple now in use, the slope of its temperature-emf curve is virtually parallel in the higher ranges of temperature in which both couples are designed to be used. Thus, the thermal-emf sensitivities are equivalent in the higher temperature ranges.

Tested against the conventional thermocouple in an atmosphere of the following nominal composition: CO...10%; CO_2...5%; CH_4...1%; H_2...16%; O_2...Nil; N_2...Balance (best for accelerating green-rot attack), exposure after 212 hours showed *only +0.13 mv. drift for the D-H thermocouple, and −7.54 mv. for the conventional thermocouple.*

When the thermal-emf of the conventional thermocouple *drops,* as in a reducing atmosphere such as this, the working temperature of the furnace controlled by it *rises.* However, when a #242-33 couple is used under the same conditions the thermal-emf remains substantially constant. This means that a furnace controlled with the new D-H thermocouple *cannot overheat and ruin charges.*

Members of the Heat-Treating and Instrument Manufacturing Industries are urged to investigate this new Driver-Harris Thermocouple without delay so that through their combined efforts all U. S. Industry can benefit. Complete technical data and application information is waiting for your inquiry. Write today to our Thermocouple Division.

*U. S. Patent No. 2,691,690

Driver-Harris COMPANY HARRISON, NEW JERSEY

BRANCHES: Chicago, Detroit, Cleveland, Louisville, Los Angeles, San Francisco In Canada: The B. GREENING WIRE COMPANY, Ltd., Hamilton, Ontario

MAKERS OF THE MOST COMPLETE LINE OF ALLOYS FOR THE ELECTICAL, ELECTRONIC, AND HEAT-TREATING INDUSTRIES

XRD-5S x-ray emission spectrometer

a proved G-E X-Ray product to make your products better

Here's proof of analytical reproducibility

Yes, here is proof — *over and over and over again* — of the analytical reproducibility of five elements in a sample of the high-temperature alloy, Thetalloy, as analyzed by the Charles C. Kawin Co. of Chicago, leading metallurgical laboratory. Reproducibility, hailed by Kawin's President A. J. Busch as "top feature", provides the day-in, day-out reliability so necessary for efficient analytical work. Whether it's product control, raw material analysis or research—G-E spectrometers have proved their value for fast, accurate quantitative determination of elements down to atomic number 13 (aluminum). Not only can you analyze in minutes or hours what takes days by wet chemistry methods, but you eliminate critical sample weighings, time-consuming separations and precipitate ignitions. This great time-saving applies over a wide range of concentrations in the fields of metallurgy, petroleum, ceramics, rubber and general chemistry. You simply place the sample in the holder, read instrument data, interpret results directly in percentage from convenient graph.

Charles C. Kawin Co.

REPRODUCIBILITY CHECK ON THETALLOY

SAMPLE IDENT.	C	Mn	Cr	W	Mo	Cu	Fe	Co
12-24-55		2.16	24.36	6.75	3.11			12.90
1- 3-56		2.16	24.35	6.69	3.09			12.88
1-12-56		2.12	24.32	6.73	3.09			12.90
1-19-56		2.14	24.21	6.60	3.07			12.88
3- 9-56		2.14	24.36	6.85	3.12			12.88
3-14-56		2.11	24.40	6.68	3.08			12.92
3-16-56		2.13	24.28	6.57	3.08			12.98
3-20-56		2.12	24.23	6.65	3.09			12.96
4- 9-56		2.10	24.35	6.74	3.08			12.93
4-10-56		2.09	24.37	6.66	3.08			12.95
4-16-56		2.13	24.29	6.65	3.09			12.98
4-18-56		2.13	24.56	6.66	3.10			13.00
5- 2-56		2.11	24.31	6.82	3.08			12.98
8- 6-56		2.13	24.29	6.59	3.08			12.88
8-10-56		2.14	24.34	6.69	3.06			12.91
8-13-56		2.16	24.33	6.59	3.09			12.91
9-28-56		2.18	24.38	6.48	2.94			12.86
10-11-56		2.14	24.31	6.68	3.09			12.98
10-19-56		2.14	24.16	6.67	3.07			12.98
10-20-56		2.14	24.31	6.78	3.03			12.95
10-25-56		2.13	24.16	6.62	3.09			12.99
11- 3-56		2.16	24.18	6.58	3.06			12.94

22 ANALYSES OVER 10-MONTH PERIOD prove reproducibility of Kawin's XRD General Electric x-ray spectrometer

This same reproducibility and speed are characteristic of the latest model General Electric x-ray spectrometer — the XRD-5S pictured above.

For a recommendation on the facilities best suited to your analytical work, contact your G-E x-ray representative. Or you can get the information you need by writing X-Ray Department, General Electric Company, Milwaukee 1, Wisconsin, Rm. AS-44.

Progress Is Our Most Important Product

GENERAL ELECTRIC

VANADIUM-ALLOYS STEEL COMPANY

FIRST QUALITY

High Speed Steels

wherever outstanding cutting performance must be matched with practical economy on industry's most exacting jobs.

Vasco Supreme — The supreme high speed steel, providing highest hardness, highest hot hardness, highest wear resistance, highest cutting efficiency. (U.S. Pat. 2,174,285)

Neatro — For heavy, light and intermittent cuts on heat-treated steels and abrasive materials. Extremely high abrasion resistance, exceeded only by Vasco Supreme. (U. S. Pat. 2,174,286)

Van Cut — Molybdenum-tungsten type, combining ease of grinding with improved wear and heat resistance. Suitable for all types of cutting tools.

Red Cut Superior — America's favorite general-purpose high speed steel. Easy to fabricate, simple to heat treat. Wide choice of carbon content, for almost limitless uses.

Vasco M-2 — The original 6-6-2 type steel. Machines easily, has wide hardening range, can be ground normally when hardened. Excellent economy in general service.

8-N-2 — Molybdenum type, low in tungsten. High toughness, for fine edged tools and sharp angles without chipping or crumbling. Substitutes well for 18-4-1.

Van-Lom — Out-cuts other high-moly steels. Special vanadium content permits increased carbon (U. S. Pat. 2,105,114) without brittleness, for greater toughness, wear resistance.

Write for useful Data Sheets

Vanadium-Alloys Steel Company

Latrobe, Pennsylvania

SUBSIDIARIES: Colonial Steel Co. • Anchor Drawn Steel Co. • Pittsburgh Tool Steel Wire Co. • Vanadium-Alloys Steel Canada Limited • Vanadium-Alloys Steel Societa Italiana Per Azioni

New

1715 AB ELECTRO POLISHER FOR METALLURGICAL SAMPLES

New **GREATER POWER**
0-5 amps usable D.C.

New **BUILT IN RECTIFIER**
Requires only 110 V., 60 C., 1 Phase.

New **IMPROVED CORROSION RESISTANCE**
Vitreous covered cell housing.

New **MODERN DESIGN**
Convenient separate units.

New **EXTRA VERSATILITY**
Power source suitable for present and future AB cells, open beaker or other polishing or etching cells.

New **IT'S ALL NEW**
Except the dependable Buehler name and service and the "made in U.S.A." quality.

Buehler Ltd. METALLURGICAL APPARATUS
2120 GREENWOOD STREET, EVANSTON, ILLINOIS

MEMO
I wonder if a longer electrode would prove more economical?
MEMO
Let's call Great Lakes Carbon--they've always been helpful, and they're good people to work with!

ELECTRODE GLC DIVISION

GREAT LAKES CARBON CORPORATION

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XX

This is the twentieth of a series of advertisements dealing with basic facts about alloy steels. Though much of the information is elementary, we believe it will be of interest to many in this field, including men of broad experience who may find it useful to review fundamentals from time to time.

Flame-Hardening Alloy Steels

When the surface of steel is subjected to direct application of flame and heated above the transformation range, then hardened by quenching, the process is known as flame-hardening. Its primary purpose is to surface-harden without affecting core properties. Jets of flame are played directly on the steel, and hardness penetration can be made to vary considerably. Usually in alloy steels this depth will range from 0.03 to 0.12 in., the actual figure depending upon the method of heating and quenching used.

Unlike carburizing, flame-hardening does not involve the absorption of extraneous elements by the steel. There is no alteration of the chemical composition. To put it simply, the steel must have its own self-hardening characteristics; cannot be dependent upon carbonaceous salt baths, gases, etc.

Flame-hardening is not a substitute for the conventional furnace method. Each has its uses. The particular virtue of flame-hardening is that the flames can be directed to localized areas. The furnace, on the other hand, is generally more economical and feasible when parts produced in large quantities must be hardened all over.

Any type of hardenable steel, alloy or carbon, can be flame-hardened, and there will usually be no scale or pitting. The alloy content is the governing factor when determining the quench. In some cases a rapid quench is required; in others, it can be as slow as air-cooling. Tempering presents no problems, for flame-hardened steel can be tempered as if hardened to the same point by other methods.

A list of typical flame-hardened parts would include such familiar items as gear and sprocket teeth, and certain types of cams and rollers, shoe treads, etc. This list is by no means exhaustive; it could include many other parts that often require a localized hardening treatment, especially for wear-resistance.

When seeking information about flame-hardening methods, please feel free to consult with our technical staff. Bethlehem metallurgists will gladly cooperate, and you can depend upon their suggestions. You can rely on Bethlehem, too, as a source of alloy steels, for Bethlehem makes the complete range of AISI standard grades, as well as special-analysis steels and all carbon grades.

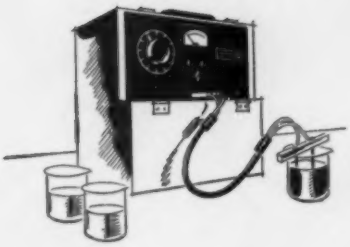
If you would like reprints of this series of advertisements from No. I through No. XVI, please write to us, addressing your request to Publications Dept., Bethlehem Steel Company, Bethlehem, Pa. The first 16 subjects in the series are now available in a handy 32-page booklet, and we shall be glad to send you a free copy.

BETHLEHEM STEEL COMPANY
BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation. *Export Distributor:* Bethlehem Steel Export Corporation

BETHLEHEM STEEL

BETHLEHEM STEEL



"Quenchol Demonstrator showed...They needed More Cooling Power to stop spotty hardness!"

A large manufacturer of locking pins recently had a problem getting uniform high hardness on SAE 1074 steel. Hardnesses varied from 34 to 61 R_c Hardness. Since this and other factors pointed to the competitive oil they were using, they asked Sinclair Representative Russell Smith for his evaluation. Mr. Smith reports:

"Spotty hardness indicated that the oil being used lacked cooling power. A comparison test on the Sinclair Quenchol Demonstrator showed that this oil had a cooling power rating of 784 . . . as compared with a rating of 1225 for QUENCHOL 521!"

This test convinced them!

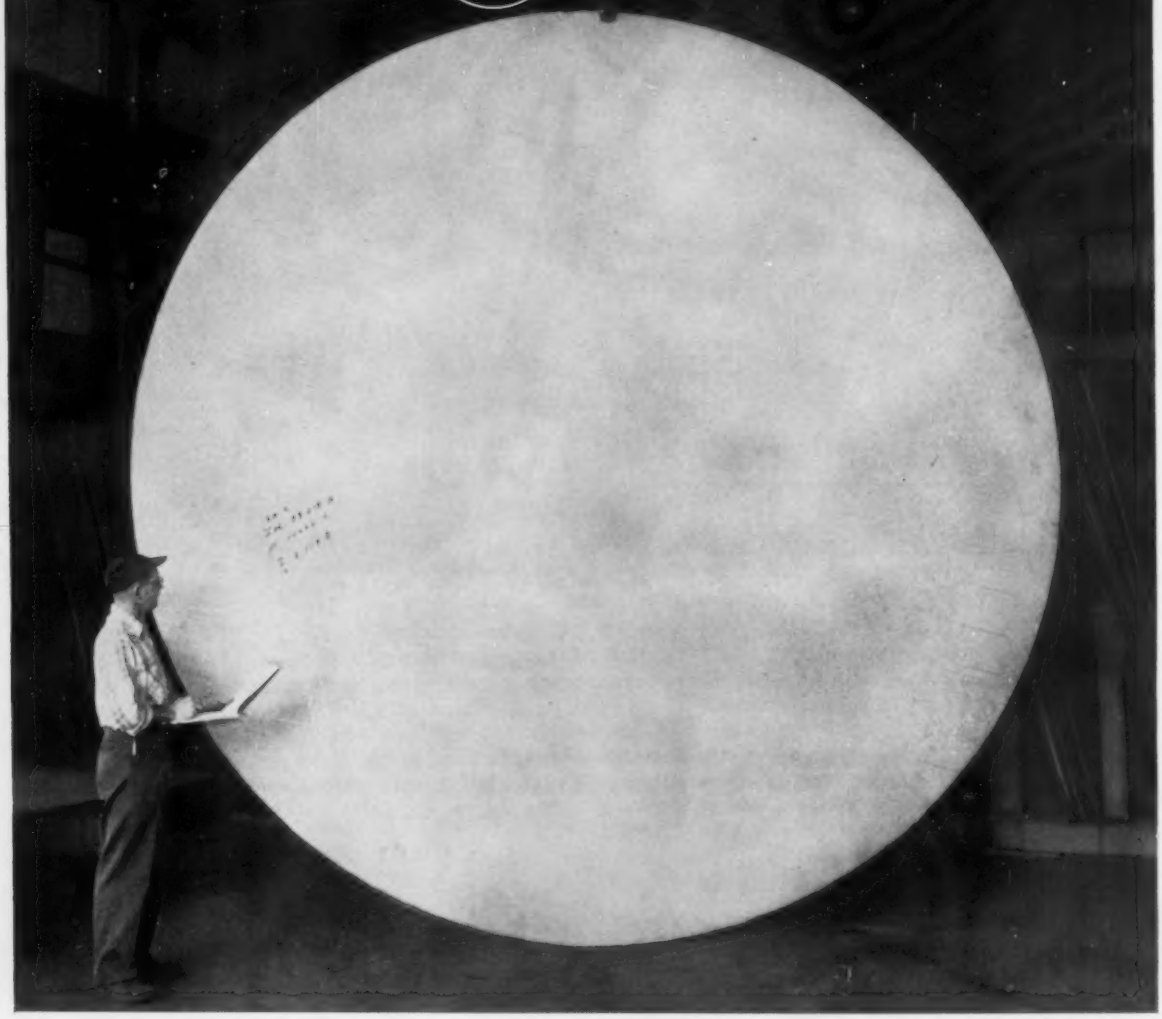
Mr. Smith continues, "The Quenchol Demonstrator test results persuaded this manufacturer to install QUENCHOL 521 immediately. Now they are getting an increased and uniform hardness range of 59 to 65 R_c Hardness. Moreover, with QUENCHOL 521 *working loads have been increased 67%*, from 3 tons to 5 tons per quench, using the identical equipment and procedures! Needless to say, this manufacturer is very pleased with the cooling power and performance of QUENCHOL!

Try a FREE Quenchol Demonstrator test on *your* present quenching oil. See how it compares with the amazing cooling power of QUENCHOL 521. Make arrangements through your local Sinclair Representative, or write to Sinclair Refining Company, Technical Service Division, 600 Fifth Avenue, New York 20, N. Y. Free literature is available, and there is no obligation.

SINCLAIR

METAL WORKING OILS

WHY BUY STAINLESS STEEL squares WHEN IT'S circles YOU NEED?



This circle, 9/16" thick x 164" diameter, is one piece of Type 316L stainless steel. Had the customer ordered a square, he would have paid freight on a half-ton of excess material. Also, he would have had the problem and expense of handling the square and cutting the circle.

Here are four sound reasons why Carlson customers save time and money when they order the circles they want—rather than the squares they have to cut . . .

1. If the gauge and size are circle-shearable, there is no extra charge for cutting the circle. This saves cutting labor and scrap handling expense.
2. If the gauge is such that a cutting charge applies to the square, it pays to order the circle. This eliminates the extra charge for cutting the original square and involves only the one charge for cutting the circle.
3. Because circles weigh approximately 25% less than squares, there's a substantial saving in transportation costs.
4. Small or medium size circles are often available from stock when squares may not be. The delivery time saved can be an important factor.

When you need stainless steel circles, come to Carlson where we specialize in stainless steel . . . that's your guarantee of dependable service.

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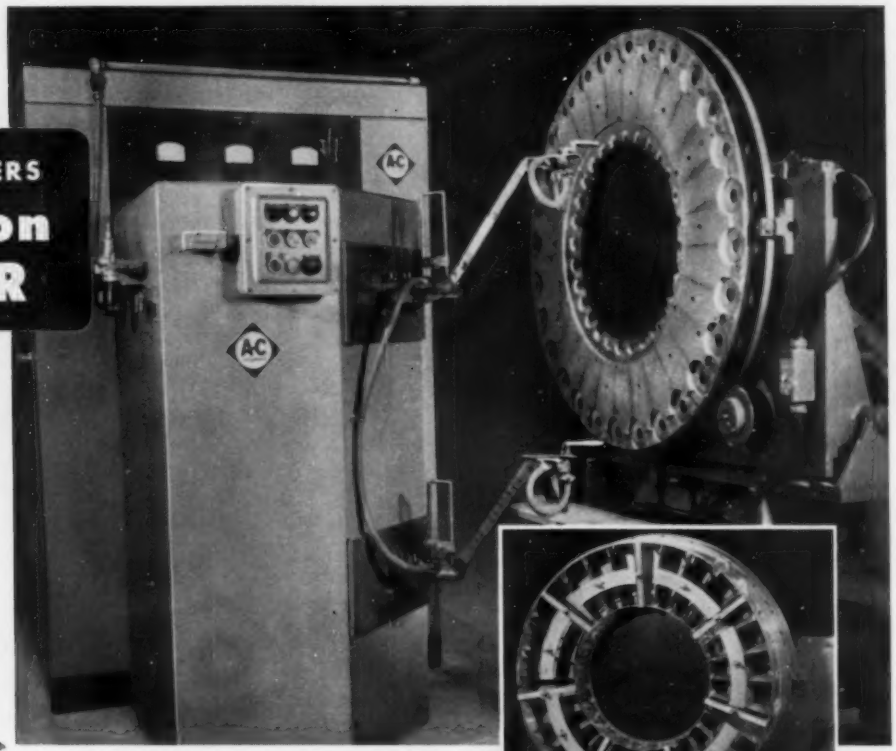

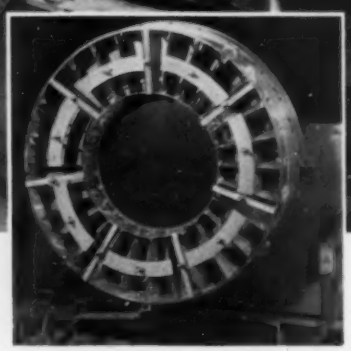

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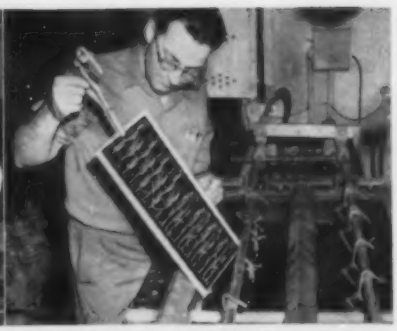

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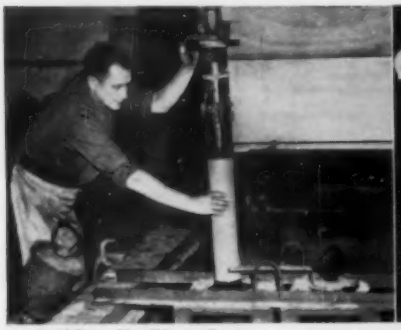

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Metal Progress
Volume 71, No. 4 April 1957

Critical Point

By the EDITOR

A Few More Engineering Graduates

FINAL (and perhaps complete) data on number of students and graduates in American engineering schools have been issued by Uncle Sam's Office of Education for the academic year ending in the spring of 1956. The figures, compared with 1955 are as follows:

ALL ENGINEERING DEGREES

1956		1955
26,306	B.S.	22,589
4,705	M.S.	4,379
610	Ph.D.	599

Figures for metallurgical degrees are not very precise, primarily because there is no official definition of metallurgy. From information collected by the ASM Advisory Committee on Metallurgical Education and by the ASM Foundation for Education and Research the following appears to be approximately correct:

METALLURGICAL DEGREES

	1957	1956	1953 TO 1955
B.S. in Met.	670 est.	600	550 (av.)
M.S. in Met.			140
Ph.D. in Met.			65

Prospects for engineering graduates in the next three years may be estimated from the Office of Education's totals of registrations in engineering courses:

ACADEMIC 1956-1957	ENROLLMENTS	ACADEMIC 1955-1956
77,738	1st Year	72,825
55,767	2nd Year	50,841
44,610	3rd Year	39,377
37,571	4th Year	31,300
1,387	5th Year (Regular)	1,358
1,838	5th Year (Cooperative)	1,450
32,210	Others	24,297
251,121	Sub Total	221,448
22,529	M.S. Graduate Students	18,482
3,402	Ph.D Graduate Students	3,163
277,052	Grand Total	243,093

The ASM estimates that there are very close to 3000 undergraduates now enrolled as metallurgists in junior and senior classes in all American and Canadian colleges and universities. This is a miniscule 3.6% of the total of all upperclass engineering students, and seemingly more metallurgists fall by the wayside, for the ratio of all B.S. graduates to engineering upperclassmen is about 31% (26,306 graduates and 85,406 upperclassmen) whereas the ratio for metallurgical engineers is only 20% (600 to 3000).

The person who gets excited about the shortage of engineers in the United States will not get much comfort from these statistics. B.S. degrees in engineering are gradually increasing in total: 21,500 in 1954, 22,600 in 1955 and 26,300 in 1956. This trend will continue, as shown by the larger enrollments in freshmen, sophomore and junior classes, but whether it will reach the 44,000 in 1960 predicted by the Office of Education may be doubted. ASM

Metals for High-Speed Flight

*By WOLFGANG H. STEURER**

At very short periods of exposure to high temperatures in terms of minutes or seconds, many metallic materials show properties far superior to those obtained in conventional tests. Consequently, they can often admirably resist the transient heat conditions encountered in guided missiles and high-speed aircraft.
(Q27a, 2-12, 3-17; SGA-h, SGA-b)

THE REQUIREMENTS of high-speed flight and the related material properties differ considerably for various types of vehicles and operational characteristics. In uniform and level flight at moderate speeds aerodynamic heating is of such a small order that the thermal and chemical effects are negligible, and a conventional structure can be designed primarily for high strength. At higher speeds, however, aerodynamic heating becomes so severe that materials have to be selected for a well-balanced combination of thermal and chemical properties, in order to maintain equilibrium between the structure and its environment. If such a vehicle performs maneuvers, the sudden increase of speed at high angles of attack will add a transient heating to the steady state conditions, which will produce high thermal gradients within the wall and thus add thermal stresses to the aerodynamic loads already present. Finally, a purely transient heating is encountered if guided missiles re-enter the atmosphere at extremely high speeds. Due to the increasing density of the atmosphere during descent, aerodynamic heating is so rapid and intense—even though brief—that its effects and secondary reactions with the environment cannot be resisted simultaneously by a single material. It becomes necessary, therefore, to separate the stress-carrying and heat resisting elements and build a composite structure.

It is obvious that metals for such high-speed vehicles must be chosen according to criteria which have little relationship to the demands of conventional engineering. The present discussion outlines very briefly the significant properties of metals in relation to high-speed flight and some potential methods for improvement.

Strength Criteria

The foremost requirement for the over-all efficiency of vehicles for high-speed flight is light weight. In the materials of construction this may be accomplished by low specific gravity, or high strength, or both. Since specific gravity is an unchangeable property of a given material, any improvement of its strength-to-weight ratio can only be achieved by increasing the strength. Before discussing potential methods of improving strength it is necessary to define the strength criteria for the various time-temperature characteristics of high-speed vehicles. Three basic characteristics of heating must be considered: *(a)* stationary heating; *(b)* transient heating; *(c)* stationary heating with one or more transient cycles superimposed.

These three types of heating have one common aspect: The total time of heat exposure is very short and consists of three phases – a period of heating, followed by a hold at almost constant temperature, and finally a period of cooling.

Several test methods have been established which attempt to produce useful strength values under close simulation of the loading and heating characteristics of high-speed flight:

1. In the "Very Short-Time Tensile Test", the specimen is brought to temperature as rapidly as possible, subsequently held there for a time, and then tested in tension in a conventional manner but at a high strain rate. Criteria are yield and ultimate strength. A series of tests, with various holding times, produces a strength-stability characteristic. The heating and loading program is shown schematically in Fig. 1 at top.

*Chief, Materials Research, Army Ballistic Missile Agency, Huntsville, Ala. This is a condensed version of a paper entitled "The Use of Metals for Structures Exposed to Aerodynamic Heating" read before the Conference on Heat Tolerant Metals for Aerodynamic Applications, Jan. 28, 1957, sponsored by the Albuquerque and Los Alamos Chapters of the American Society for Metals, and the University of New Mexico.

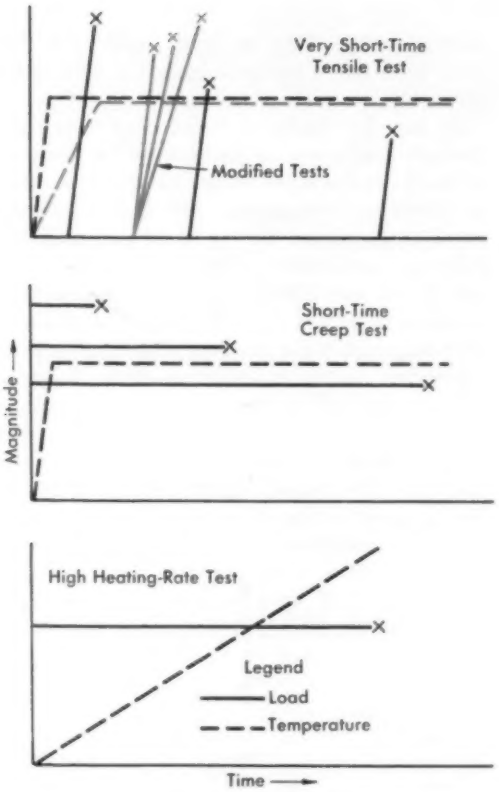


Fig. 1 – Temperature-Load Programs for Various Short Heating Tests

2. In the "Modified Very Short-Time Tensile Test", the basic procedure is the same as above, but various rates of heating and loading are introduced, as shown in color in the top diagram.

3. In the "Short-Time Creep Test" (Fig. 1, center) the procedure is identical to the conventional creep test at constant load, except that temperatures or loads are high enough to reach critical deformations within short periods of time. Criteria are time-to-rupture and limits of total deformation. The latter may serve designers as a substitute for the yield strength at temperatures where its determination in the very short-time tensile test becomes difficult.

4. In the "High Heating-Rate Test" (Fig. 1, bottom)* the load is constant and the temperature is raised at a certain rate until fracture occurs. Strength criteria are total deformation limits and rupture for various rates of heating.

5. In the "Very Short-Time Hardness Test", the procedure is identical to Fig. 1 at top, except that a hardness test replaces the tensile test.

*Developed by W. K. Smith, C. C. Woolsey and W. O. Wetmore and described in *Transactions* ASM, Vol. 44, 1952, p. 689.

For investigating the relationship between the time of heat exposure and the stability of various strengthened microstructures, the very short-time test appears to be preferable for the following reasons:

1. The change of properties with time and related metallurgical phenomena can be easily observed and interpreted.

2. Heating and cooling periods can be disregarded since they are usually very short compared with the holding time. Furthermore, only a part of the heating and cooling phase is in a metallurgically significant temperature range.

3. Results are closely related to those from conventional tests, which permits direct comparison and provides the designer with familiar designations.

Strength for Short Heating Times

Unalloyed Metals – If a highly pure and fully annealed metal is exposed to high temperatures short of melting, its strength will immediately be definitely lowered, since temperature increase and loss of deformation resistance are closely interrelated in the physics of atomic structure. There will, therefore, be no time effect in the strength, even at very short times.

However, as soon as small impurities are present – as in "commercially pure" metals – a distinct strength-time relationship can be observed at certain temperature levels. This may be due to gradual dissolution of some of the impurities at the higher temperature or, on the other hand, a precipitation of second phases from a metastable solid solution. These are usually transient effects.

A typical example is in Fig. 2, showing very short-time strength of a commercially pure titanium when tested at various temperatures after 1 sec., 15 sec., 40 sec., and 900 sec. at heat. At 200° C. there appears to be a softening effect which reverses and strengthens the metal after 100 sec. As the temperature is raised, the strength is maintained for shorter periods of time followed by a gradual decrease which may be explained as the dissolution of a well-dispersed precipitate. At 600° C., this dissolution process is very apparent and the age hardened structure is now stable for only about 40 sec. At 700 and 800° C., another transient aging effect can be observed, which reaches a peak at about 60 sec. exposure, followed by the usual decrease to the conventional short-time tensile strength.

These tests indicate that a value obtained at any one time cannot be projected to another time. In the present case, a test at 800° C. and

60 sec. exposure would show a strength of 12,000 psi. One is inclined to take for granted that this value includes all exposure times up to 60 sec. Figure 2 proves that this is incorrect, as the strength at 1 sec. is only 8000 psi.

The above effects suggest the following preliminary statements:

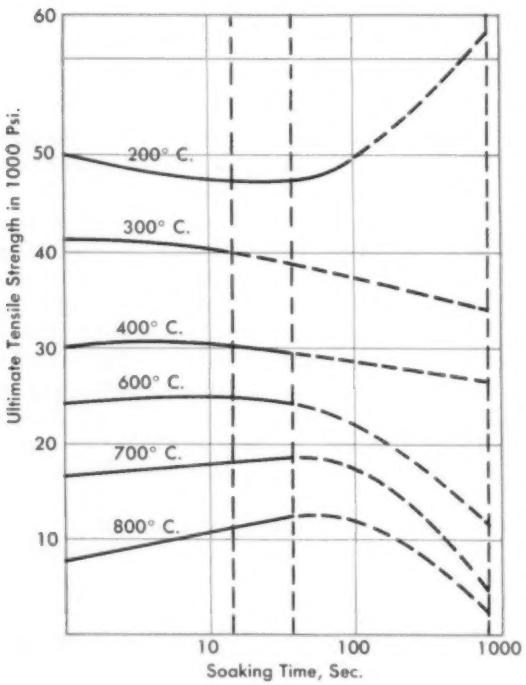
1. Some additions to metals, such as impurities, may produce transient precipitation hardening effects, which may increase the strength for short exposures to heat.

2. The stability (life) of these transient structures decreases at higher temperatures.

3. Peaks may occur in the strength-time curves at certain temperatures and times at temperature. A single test at a given time does not permit extrapolation or even prediction for shorter periods.

Precipitation Hardened Metals – In view of the favorable effect of transient aging caused by small amounts of solute impurities, the gain in strength at very short times is expected to be considerably higher in typical age hardening alloys. Of fundamental significance is the stability of the effect for very short times. As to their influence on creep, the highly strengthening finer dispersions have poor stability, while coarse precipitations are very stable yet they contribute little, particularly in the coagulated form, to deformation resistance.

Fig. 2 – Tensile Strength of "Commercially Pure Titanium" After Short Periods of Exposure to Various Temperatures Without Cooling



It can be easily deduced that short-time strength and stress to rupture, in the presence of finely dispersed precipitations, are higher than long-time rupture values. This is demonstrated in the tests shown in Fig. 3 of annealed and fully age hardened Cu-Ni-Si alloy, wherein rupture in 0.1 and 1000 hr. is plotted against temperature, together with the ratio of short to long-time values as a measure of the gain at brief exposures. In the annealed condition, the gain is moderate and in the order of commercially pure metals already described. In the fully aged condition, however, the large gain indicates the initial presence of highly strengthening, yet highly unstable, fine dispersions.

Further evidence that a properly dispersed secondary phase will improve the short-time strength is had from tests on age hardened Al-Cu-Mg alloy 2024-T 3. Representative values are as follows:

	Ultimate	Yield
Tested at 100° C.		
15 sec.	65,000 psi.	48,000 psi.
150 sec.	65,000	48,000
Long time	60,000	45,000
Tested at 200° C.		
15 sec.	52,000	43,000
150 sec.	49,000	39,000
Long time	27,000	22,000
Tested at 300° C.		
15 sec.	33,000	27,000
150 sec.	26,000	18,000
Long time	11,000	9,000

As emphasized before, values obtained at comparatively large time increments may conceal discontinuities. Further investigation by means of the very short-time hardness test, Fig. 4, discloses a number of discontinuities whose correct interpretation is almost impossible. They indicate several superposed secondary precipitations and transient effects (in addition to the primary age hardening) depending on the amount and combination of impurities. Test results such as shown in Fig. 4 may change considerably within the impurity limits of the commercial alloy.

Metals Hardened by Metastable Transformation – Experience with age hardened microstructures leads to the assumption that other strengthening yet unstable phenomena in metals, such as heat treating or strain hardening, will produce a similar effect. For higher carbon steels, the commonly used diagrams showing the hardness of a steel after tempering at succes-

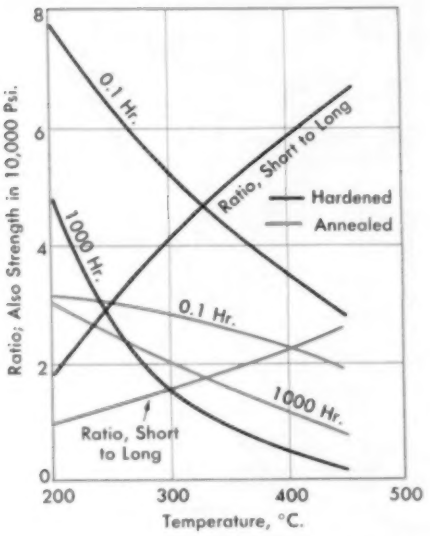


Fig. 3 – Stress to Rupture of Annealed and of Precipitation Hardened Copper-Nickel-Silicon Alloy, at Various Times and Temperatures. (Jenkins, Bucknall, Jenkinson, Journal *of the Institute of Metals, Vol. 70, 1944, p. 57)*

sively rising temperatures may serve as a means for the appraisal of the stability of various heat treatments. For A.I.S.I. 1095, for example, the Brinell hardness at various tempering treatments is as follows:

	Water Quenched	Oil Quenched
Tempered at 500° F.	600	385
750	410	365
1000	270	330
1250	200	245

The harder (and stronger) martensitic structure loses its advantage over the intermediate microstructure obtained by oil quenching at about 800° F., which is more stable. A cautious projection of these facts to short-time behavior would lead us to expect that the martensitic and stronger structure will persist for *short* periods of exposure even beyond the critical temperature A_1, while the weaker intermediate structure will be stable for longer times.

The correctness of this assumption is proved by high heating rate tests on heat treated and normalized A.I.S.I. 4130, when compared with the conventional short-time values, as shown in Fig. 5.

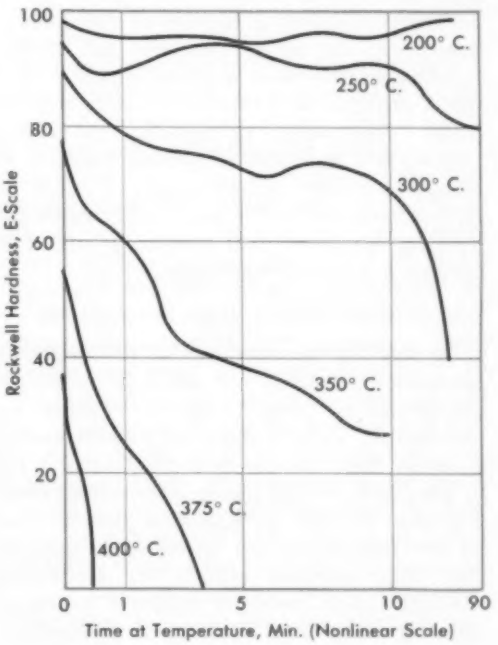
It appears that when choosing materials for structures which will be heated for a short time the heat treatment must be selected according to the stability of the resulting microstructure and the maximum exposure to both time and temperature.

Cold Working – The loss of the strengthening effect in cold worked metals at elevated temperatures is related to recovery and recrystallization. Even though it is often difficult to distinguish between the two phenomena, particularly in alloys, it is obvious that the cold worked structure is much more stable at temperatures below recrystallization. Furthermore, the rate of recovery increases with the amount of cold working and the temperature. This confirms the idea that the higher the strengthening effect, the lower the stability.

These relationships were investigated in very short-time hardness tests on copper, whose high purity minimized other influences on recrystallization. The effect of temperature is demonstrated in Fig. 6 at left. Even though all test temperatures are above recrystallization (about 220° C. at 80% reduction), there is still a distinct response to temperature. For the very short times involved, the cold working effect remains fairly stable up to 300° C. At extremely short times (15 sec.), useful mechanical properties are indicated even up to 400° C.

The effect of the degree of cold working upon the stability at 400° C. is presented in Fig. 6

Fig. 4 – Variations in Hardness With Time of Aluminum Alloy 2024-T 3 at Various Temperatures



at right. As expected, the stability limit moves to shorter times as the degree of cold working is increased. For practical applications, again, a proper degree of cold working has to be selected for each specific combination of temperature and time.

General Principles – As has been demonstrated by the foregoing, the principal means of strengthening for service for very short times differ basically from the conventional methods aimed at lengthy service. Strengthening for long-time service is usually achieved by alloying. The strengthening effects imparted by operations such as heat treating, age hardening or cold working are unstable, particularly close to and above certain critical ranges (transformation temperature, aging temperature, recrystallization temperature). For short-time service in high-speed vehicles, however, heat treatment is the principal means for improving strength; alloying may be used in addition to improve the strengthening capabilities of a metal.

It has been further demonstrated that the stability of the structure so strengthened declines with increasing strengthening degree or with increasing temperature. This implies that for a given service time at a given temperature there is an optimum degree of strengthening or optimum treatment which will produce the highest strength for the required service time.

In practical applications, determination of the proper treatment requires accurate knowledge of the relation between the stability characteristic and various degrees of strengthening treatment. It further requires an accurate analysis of the manufacturing process, which often changes the properties of a treated material. For example, to apply the cold working process it is necessary to provide materials for manufacture at a proper hardness which, together with the subsequent cold working in forming operations, will produce a part of the desired hardness and strength.

Use of Metals at Very High Temperatures

At very high temperatures, all the mechanical properties of metals and alloys are extremely dependent on time. Ultimate strength and particularly yield strength, as defined conventionally, begin to lose their significance. Due to the relatively high plastic deformations resulting from the first application of stresses, *limits of total deformation* are not only convenient but the only practical criteria for establishing strength values useful for design of high-speed vehicles. The total deformation is composed

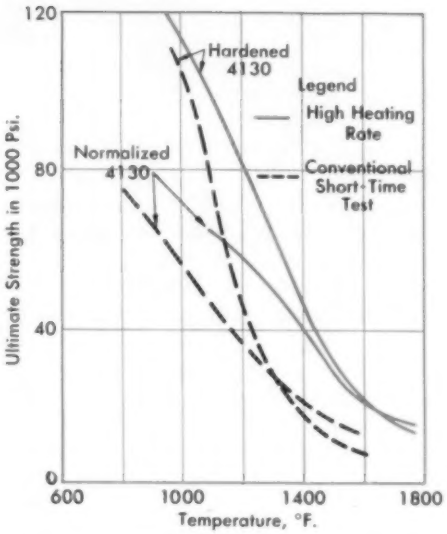


Fig. 5 – Comparison of Stress-to-Rupture Tests at High Heating Rates With Conventional Short-Time Tensile Tests. Steel is A.I.S.I. 4130 (1% Cr, 0.25% Mo), both in hardened and normalized condition

of the elastic deformation, the initial plastic deformation upon stress application, and the deformation due to creep. (Deformation caused by thermal expansion is omitted, since this is an obvious attribute of design for elevated temperatures.)

In those applications where load and temperatures are constant and concurrent, the short-time creep test will produce useful values for design, particularly if enough data are obtained for establishing complete interrelation between temperature, load, time and deformation.

For transient heating, where both temperature and load are varying, the high heating-rate test outlined in the early part of this article provides a close simulation as long as temperature and load are concurrent. However, they are usually out of phase. Unless very specialized test equipment can exactly reproduce the temperature-load program, it is necessary to forecast the expected total deformation with data obtained in short-time creep tests, either by calculation or graphically.

As the temperatures are further increased, the metallic materials will enter the plastic state, and no longer be able to carry structural stresses. On the other hand, their thermal or other properties may still be highly attractive. This leads to the conception of a composite structure, consisting of a stress-carrying substructure, protected against excessive temperatures by a

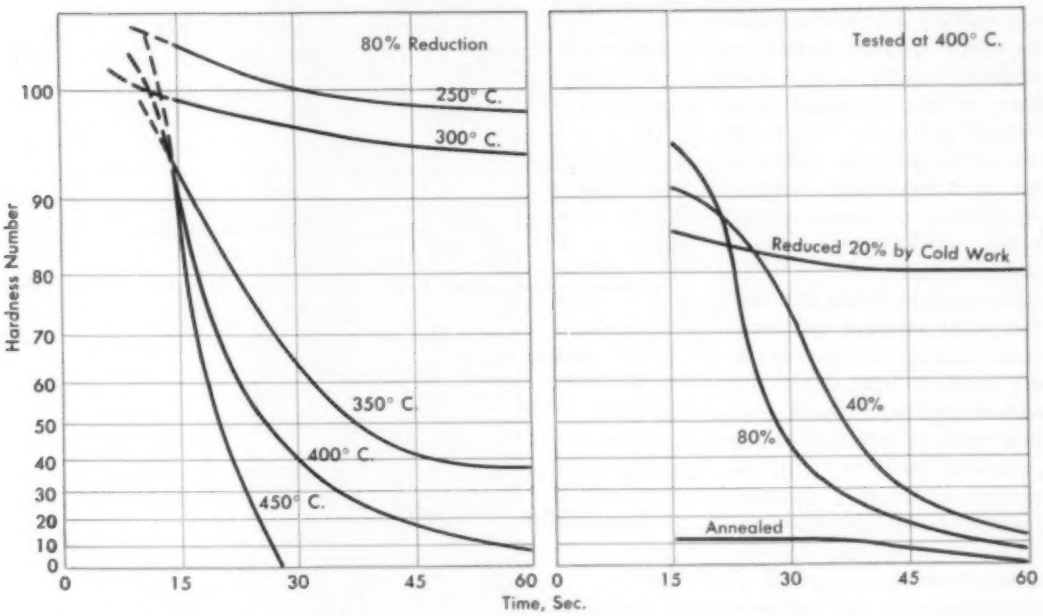


Fig. 6 – Stability of Cold Worked Structure in Pure Copper, as Measured by Hardness in Relation to Temperature, Time at Temperature, and Amount of Cold Reduction

heat shield designed with little regard to its mechanical properties.

If the heat shield is highly effective, the stress-carrying substructure may not be heated at all, which permits us to return to conventional designs. In other vehicles, particularly under stationary heating conditions, the substructure may be heated considerably – in fact enough so that the designer can apply the criteria for strength improvement for short-time service discussed in the preceding section.

Heat Protection and Absorption – The role of the protective superstructure places emphasis on the selection of materials because of their favorable thermal properties. Since the thermal conductivity of metals is generally high (compared with nonmetals) they are of little use as insulators. For transient heating, however, their specific heat and thermal capacity may serve as temporary heat absorbers. For this, one cannot judge on the basis of specific heat alone.

First, additional heat may be consumed by crystallographic transformations, due to their endothermic nature. Though the amount of heat required for a single transformation is small, in alloys with several phase changes it may add up to a considerable amount.

Second, for effective heat absorption, heat must be removed rapidly from the surface into the bulk of the material. This is expressed by its thermal diffusivity, $a = \frac{k}{c\gamma}$ where k is the conductivity, c is the specific heat and γ is the specific gravity. This relationship places equal importance on the thermal conductivity.

It is further obvious that the useful temperature range has to be taken into account. Its ultimate limitation is, of course, the melting temperature.

In approaching the melting point nearly all metals exhibit extremely poor resistance to deformation. In the temperature range close to melting, though still part of the solid state, they may even change to a viscous behavior. In this semisolid state the surface layer of the skin material may shift or even be completely removed by the mechanical forces of the air flow.

To understand this effect it is necessary to take a look at the interrelation between the environmental conditions and the material during high-speed flight, as illustrated in Fig. 7.

The original components of the free stream, after passing through the shock front and the flow region, arrive in a modified condition in the boundary layer: Pressure and density have increased considerably; the temperature reaches a peak near the metal surface representing an equilibrium between the stagnation temperature and the cooling effect of the surface. While the proportion of the component gases will be re-

tained, the degree of dissociation will be increased according to the boundary layer temperature. Finally, we arrive at the material surface with *(a)* a certain gas pressure, *(b)* a certain temperature and heat flux, *(c)* a certain gas composition, partly molecular, partly atomic, and *(d)* a certain flow pattern.

On the side of the skin material, the pressure will generate structural stresses, while the air flow will subject the surface layer to shear stresses. The heat flux into the surface governed by the intricate mechanism of heat transfer, produces a certain surface temperature, depending on the emissivity of the skin and heat dissipation into the bulk material. This in turn will create a certain temperature distribution through the wall, depending on thermal conductivity and specific heat. A secondary effect of the temperature gradient within the wall is thermal stresses, particularly at high heating rates, which will add to the mechanically produced structural stresses. The composition and degree of dissociation of the atmospheric gases finally will result in chemical surface reactions such as oxidation or gas absorption.

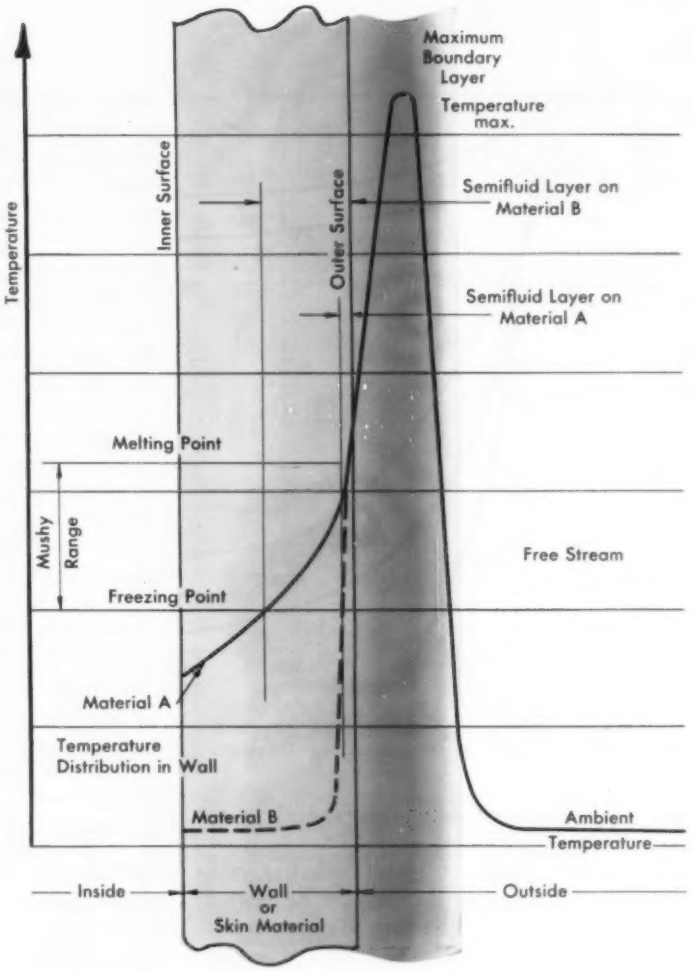


Fig. 7 — Schematic Representation of Heat Exchange Between Environment and Skin Material

Figure 7 also demonstrates the limitations that exist in the use of different metals as soon as they enter the semisolid state. This figure sketches conditions for two materials, A and B, that have the same melting point and the same extent of the semisolid temperature range, but that have different thermal conductivity. Due to the steep thermal gradient in material A, only a small surface layer will be in the semisolid state and thus likely to be removed. In material B, whose thermal capacity and dissipation are much superior to metal A, half of the wall thickness will be in the semisolid state. For a sound design of a heat-absorbing superstructure, an optimum balance between heat content, thermal conductivity, and temperature limitations must be sought.

Another thermal property of metals which may be used to advantage, particularly under stationary heating conditions, is their high reflectivity. A considerable amount of heat may be removed by radiation if the superstructure consists of elements of high reflectivity, covered by a shield possessing high emissivity at the outer surface. The use of metallic materials for reflectors at high temperatures depends on their oxidation resistance, since even the smallest amount of oxide will reduce the reflectivity considerably.

Nonmetals are superior to metals for insulation, but use of ceramics is often limited by their poor erosion resistance. It will be often necessary to provide them with a metallic cover, which can be selected without regard to mechanical and thermal properties, as long as the temperatures do not go beyond the solid state. Since the surface temperatures may be extremely high, oxidation resistance may be of primary concern.

Thus it develops that surface phenomena and surface properties are the foremost criteria for the performance of materials in high-speed flight. They will, therefore, be listed and discussed briefly:

Chemical surface phenomena depend first on the composition of the environment and its degree of dissociation. The effect of oxidation upon the performance of a material is not identified solely by its oxidation rate, but also by the thermal properties of the oxides (emissivity, conductivity) and its adherence. Gas absorption may lead to a change of mechanical properties (embrittlement) in a number of metals. The effect on the bulk material is related to the depth of penetration.

Physical surface phenomena and properties may, contrary to the chemical, be used to advantage to reduce temperatures. A high emissivity, particularly in metals with a high thermal gradient and consequently very high surface temperatures, may remove a considerable amount of heat by radiation. (This applies almost exclusively to longer operations where equilibrium is obtained.) Endothermic surface reactions are of transient nature and apply thus only to transient heating. Such reactions may occur in the solid state, or may even include surface melting. The latter can only be tolerated in the presence of a very high thermal gradient, in order to confine the destructive effect to a minute surface layer.

Mechanical surface phenomena include surface deformation, which is of foremost interest. Plastic deformation is induced by shear forces on the air flow, increased somewhat by the stagnation pressure which eases the flow in the material. Shifting of the surface layer becomes severe as soon as the temperature range of semisolidity is reached. In this state materials are nearly viscous. Since viscosity by definition is associated with a complete loss of shear strength, the mechanical resistance of materials in this range must be extremely poor.

Erosion, a typical surface phenomenon, is the combined effect of pressure and velocity of the gases on the boundary layer. From this viewpoint it is a purely mechanical effect of surface stresses, loosening of particles and their removal — sometimes aggravated by an adverse flow pattern (turbulence). Metals, unlike most nonmetallics, are generally highly resistant to erosion, unless the gases carry liquid particles (for example, rain). This may result in impact fatigue and an accelerated loosening of crystallites at the surface.

Extreme Temperatures

At extreme speeds, aerodynamic heating may induce temperatures which no material, metallic or nonmetallic, will withstand. It is then necessary to absorb enough of the heat flux that the skin material stays within its useful range. For a prolonged exposure to such high heat flux rates, effective absorption can only be achieved by a special cooling system. For transient heating, however, heat may be absorbed by the material itself. There is some possibility of heat absorption by the thermal capacity of the material or by endothermic reactions. A number of metallic materials appear very promising due to their high specific heat and high melting temperature. As soon as melting occurs, however, the high conductivity (that is, the low thermal gradient) would immediately carry the melting into the bulk material and soon lead to destruction.

The exceedingly desirable combination of a high heat capacity and a high thermal gradient, which would confine any destructive process to a surface layer, can only be achieved by artificial combination of metallic and nonmetallic materials. This places emphasis on heterogeneous materials and the development of cermets with specific combinations of thermal properties.

The Place of Metals

Even though ceramics and other nonmetallic materials are of increasing importance for high-temperature applications, metallic materials will be given preference wherever possible in view of their highly developed technology, their strength and ductility, and their favorable surface properties. The present discussion has indicated three major fields of application of metals for structures exposed to severe aerodynamic heating:

1. As structural material simultaneously for stress and heat resistance, particularly with very short-time heat exposure, where unconventionally high mechanical properties can be produced.
2. As heat protecting or heat absorbing elements of a composite structure.
3. As heat absorbing materials for extremely high temperatures, particularly in combination with nonmetals in a heterogeneous part. These applications require a distinct deviation from conventional concepts. The designer moves from a part which will last a lifetime to one serving only minutes or seconds, or wherein metals assume a functional role in the fight against heat.

Metallurgy at Canada's "Mines Branch"

*By HAROLD J. ROAST**

Fifty years ago a research organization was authorized by the Canadian Government. Now its personnel numbers over 600 in the six divisions, of which 146 are in Physical Metallurgy – a term broad enough to include foundry practices on the one hand and super-purity metals on the other. (A9h)

THIS YEAR MARKS the silver anniversary of Mines Branch, the leading governmental research institute in Canada devoted to minerals and metals. It is a section of the Department of Mines, created by the Geology and Mines Act of the Parliament of Canada in 1907. Eugene Haanel, pioneering investigator of electric furnace smelting, was the first director of one of the departmental divisions, then as now called Mines Branch. His directive was ". . . to make such chemical, mechanical, and metallurgical investigations as are found expedient to aid the mining and metallurgical industry of Canada".

A review of its performance during the intervening 50 years indicates that this objective has been ably pursued.

In 1914 the complete staff totaled 41 persons. In 1915 a metallographic laboratory for the examination of steel and other alloys was established. In 1939 the "Physical Metallurgical Research Laboratories" were opened and staffed with three engineers and one handyman. By 1946 this department was housed in a two-story building with 20 research engineers assisted by 50 technicians. It was at this time that a group of Mexican governmental representatives visited the laboratories and were so impressed that upon returning to Mexico it was decided to duplicate the setup.

*Consulting Editor for *Metal Progress*.

At this time the governmental department known as "Mines and Technical Surveys" is headed by a cabinet minister, the Honorable George Prudham. Mines Branch is under the direction of Dr. John Convey and is subdivided into six divisions in addition to two general service groups and a Navy Section, as follows:

DIVISION	PERSONNEL
Mineral dressing and process metallurgy	108
Radioactivity	64
Industrial minerals	41
Fuels	71
Physical metallurgy	146
Mineral resources	38
Maintenance	70
Administration	65
Navy section	15
TOTAL	618

Of these 618, nearly 300 are highly qualified scientists.

As noted at the outset, the first obligation of the Mines Branch is to the Canadian Government, including all defense services, the Department of Transport, and the Canadian Atomic Energy Commission. After these, the Mines Branch serves, to the best of its ability, any who come to it for consultation. Naturally, nearly all of this extra work is for Canadian citizens and firms, the solution of whose problems would appear to be of interest to an important segment

of the Commonwealth. At least one rather extensive investigation was sponsored and largely financed by associations of paper manufacturers in both Canada and the United States. Much work is being done on problems arising in the St. Lawrence Seaway and Power Project.

Responsibilities of the Mines Branch are ever increasing, particularly along the lines of the processing of Canadian ores, currently those of uranium, and the various investigations associated with radioactivity. All this means a greater demand for chemical control in the extraction of values from low-grade ores by such processes as flotation, leaching, purification and reduction to metal. The new building beyond the smokestack in the aerial view on p. 76 is devoted to this; it is the largest of the present structures.

John Convey, Director, Mines Branch, Department of Mines and Technical Surveys, Dominion of Canada

Work in Metallurgy

It is appropriate that an article in *Metal Progress* should emphasize the equipment and work being done in the Physical Metallurgy Division rather than attempt to cover the Mines Branch as a whole. Many visitors to this division have expressed surprise at the number and diversity of equipment under one roof.

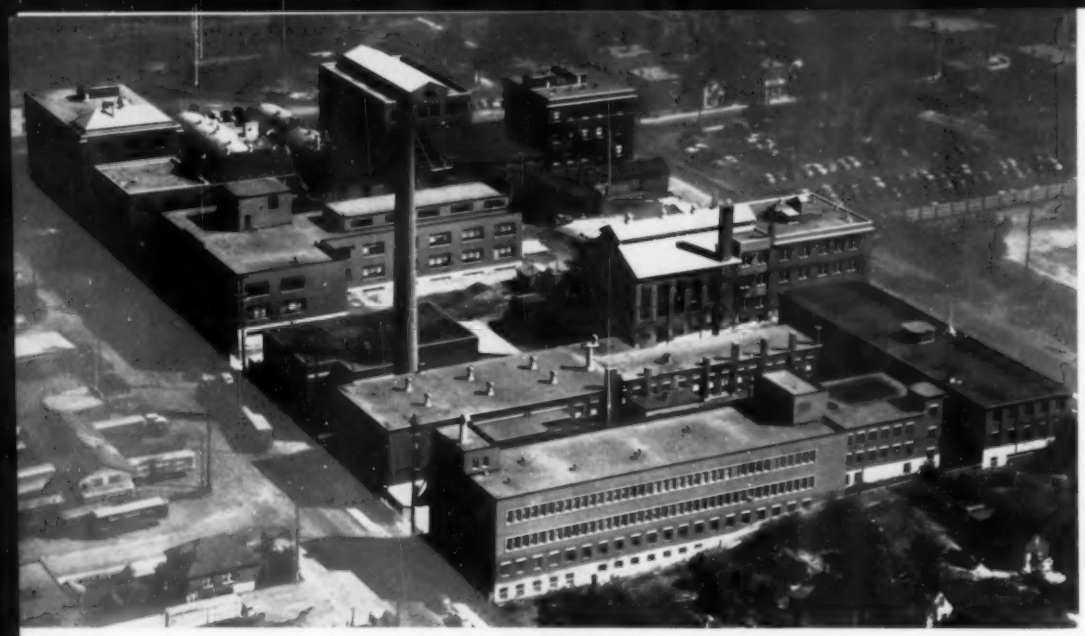
The Division's building is divided into five areas with a total floor space of some 120,000 sq.ft. The latest scientific instruments include facilities for photo-elastic stress analysis, and highly specialized devices for safe handling of radioactive materials. Rolling textures of uranium metal are studied by X-ray diffraction and microradiography.

While much research in metals is done on very small samples, Mines Branch has always prided itself on its ability to test a new idea by production on a pilot-plant scale. Hence, a rather unusual line-up of mill equipment is available in the Physical Metallurgy Division. (It will be seen that Dr. Convey defines "physical metallurgy" to include a considerably broader scope than "science of metals" or "physics of the metallic state", toward which the term seems to be tending south of the border.) Consequently one finds here completely equipped steel and bronze foundries capable of making castings weighing up to 1000 lb., together with all the necessary heating and heat treating furnaces. An area of some 7200 sq.ft. houses an outstanding set of modern machinery for almost all kinds of metal forming. It includes a two-high and a four-high rolling mill, each one reversible, for hot rolling or cold rolling of sheet, strip, and bars; also a 750-ton extrusion press. Adjacent to this is a forging hammer, and a 500-ton, double acting hydraulic press for forging, forming of sheets ("stamping") and manufacture of power metallurgy compacts.

We now turn to the results that have been obtained.

Pure Metals – In pre World War I days the metal requirements of the engineer were much fewer, simpler and less exacting than now. For instance, at the turn of the century any "bare metal" (that is, nonprecious metal) of 99% content was considered "pure", and little attention was paid to the 1% of impurities. Then 99.9% become a common standard. When electrolytic zinc reached "four nines" (99.99%) one thought that no further refinements were likely to be required. However, with the splitting of the atom came the necessity for uranium and other metals of most extreme purity, certain neutron-absorbing impurities having to be limited to 1 part per million and even 1 part per billion. Now that atomic power plants have been definitely established as both practicable and advisable, we can no longer look upon really *pure* metals as a matter of only scientific interest.

While much of this work is of a "classified" nature and not available yet for discussion or publication, one item is illustrative – a unit for the refining of lithium by distillation. This consists of a retort of alloy steel, connected to a diffusion pump and a mechanical pump. A vacuum of 0.05 micron can be obtained. Batches of 5 to 10 lb. can be treated. The maximum temperature is 2100° F. Lithium containing



Air View of Group of Buildings Occupied by Canada's Mines Branch. The administration building is at lower left-hand corner; most of the metallurgical work is done in the buildings in the foreground. The large building beyond the smokestack houses work on chemical control of extractive processes

0.50% sodium can be brought to a sodium content of 0.002%.

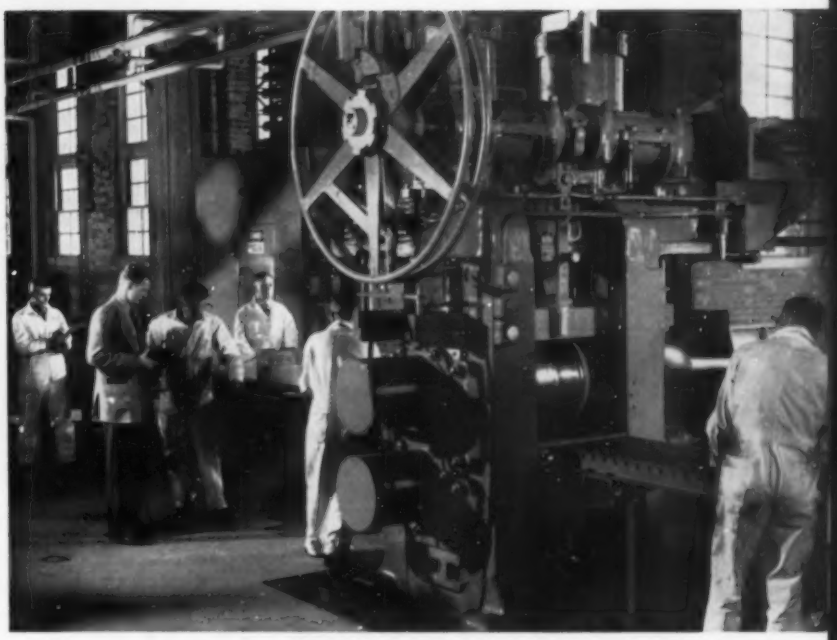
Foundry Processes – Men in the Mines Branch have been interested in many aspects of foundry work. While commercial foundries are usually quite well equipped to handle the simple items that are ordered over and over again, the advent of the gas engine, the airplane, and now the jet engine has established immeasurably higher standards. Melting under controlled atmospheres, pouring at precise temperatures and rates, controlling the solidification rate in relation to the section or mass of metal, molds of highest dimensional precision and surface finish – all these are now required of foundrymen before they can produce consistently the really high-grade castings required by the jet engine age.

New and stronger light alloys are also needed. In this field the Mines Branch has produced the high-strength magnesium alloy known as ZK 61 in Canada and specified by the American Society for Testing Materials as ZK 61 A. This alloy has a strength-to-weight ratio (for ultimate strength) of 26 as compared to a strength-to-weight ratio of 14 for low-alloy steel, 16.7 for "S" Monel, and 16 for aluminum bronze. Today's demand for more speed and less weight indicates the importance of this alloy. It is no use saying that these refined alloys are too much trouble to handle; as already stated, modern conditions, especially in aircraft, demand the best. Furthermore, it should be realized that, through such mediums as the American Society for Metals, American Foundrymen's Society and others, the

Quenching the Hot Ends of Several Pieces of Hollow Drill Steel Throws Jets of Water and Steam Out the Top End

accomplishments of one country become available to all.

Synthetic Iron Ore – The Physical Metallurgy Division did a considerable amount of large-scale work at the request of the Consolidated Mining and Smelting Co. of Canada Ltd. to determine whether pig iron and steel derived from an iron oxide calcine would meet existing specifications. The calcine itself is a byproduct of the lead and zinc smelter at Kimberly, B. C. The resultant steel was examined for forging and rolling characteristics in the life-sized mill. Hot tensile and bend tests were used to ascertain whether the steel was hot short, as predicted it might be from residual sulphur. A thorough metallographic study was made of the inclusions, the microstructure, and the ferrite and austenite grain sizes. Tensile tests at room temperature were performed and impact transition temperatures were determined. The susceptibility of the steel to strain aging was investigated.



Experimental Two-High Reversible Rolling Mill in Metalworking Laboratory

After submitting this steel to all these searching tests it was found to compare favorably with normal mild steel.

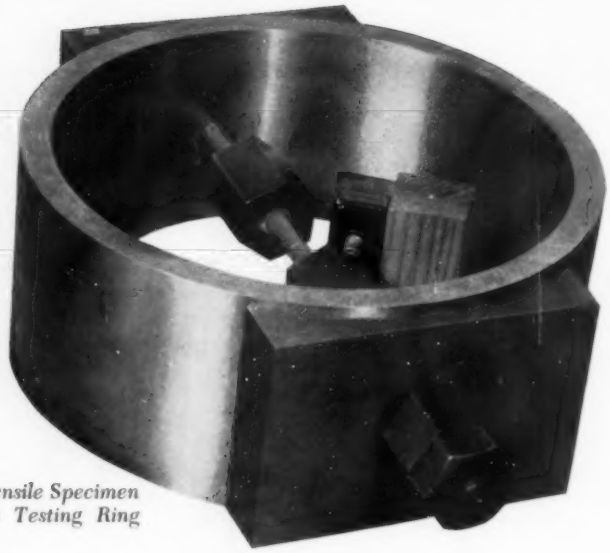
As a result of the study of the manufacture of hollow drill steel, a "spiral rolling" method has been devised resulting in a very considerable increase in the life of such tools in hard rock mining. Heat treatment of such drills, at the mine, is often still done by the rough-and-ready blacksmith's forge, so metal which can stand literally all kinds of abuse is necessary to the Canadian mining industry, now running at top speed and continually expanding.

International Cooperation – An example of cooperation between Canada and the United States may be cited: It was desired by the Army Command to improve mortar bases – especially to make a lighter one for one-man packing. A forging alloy of aluminum was developed by the Physical Metallurgy Division which was so superior that it was adopted by the Pentagon. Progress did not stop there. This was followed by a cast magnesium alloy, giving a base with still greater strength and lightness. Casting rather than forging is a distinct advantage, for in times of emergency bottlenecks frequently develop in the forging industry, while castings are more readily available.

Another instance: Concerned with the short life of alkaline sulphate digestors, the Pulp and Paper Associations of both Canada and the United States undertook a thorough investigation. The undertaking cost some $500,000 and took two years to complete. The responsibility for all investigations of a metallurgical nature was entrusted to the Physical Metallurgy Division of the Mines Branch. Through the combined effort of all those who were associated with the project pulp digestor life has been greatly increased.

Conclusion

From the equipment and activities so sketchily described, it is evident that the metallurgical investigations in the Physical Metallurgy Division of the Mines Branch cover a very wide area. However, fine scientific equipment is of no use except in the hands of men of high caliber, such as form the staff of the division. Even these same scientists, like skilled members of an orchestra, function best under a director of high qualifications and broad human interest. Such a one the "Mines Branch" has in the person of Dr. John Convey.



Notched Tensile Specimen Stressed in Testing Ring

Embrittlement (?) of Phosphated Steel

*By HAROLD P. WEINBERG and THOMAS J. CAPELLO**

Embrittlement of Cr-Ni-Mo steel, F.S. 4340 heat treated to high strength, by phosphate coating of either zinc base or manganese base can be prevented by aging 24 hr. at room temperature or by baking 1 hr. at 220° F. (Q26s, L14b; AY)

FOR MANY YEARS producers of phosphate-coated parts of high strength for the Navy have been required to heat treat them to prevent embrittlement. Although many investigations have been conducted on embrittlement resulting from other coatings, such as cadmium and chromium, and the methods used for its prevention, a review of the literature showed no similar information relative to phosphate coatings.

*Mr. Weinberg is assistant project manager for materials research and development at the U.S. Naval Gun Factory, Washington, and Mr. Capello is chemical engineer in the Bureau of Ordnance of the U.S. Navy Dept.

It was therefore decided to investigate the conditions under which phosphate coatings induce embrittlement and what treatments are required to prevent embrittlement when it occurs. It was further decided that the effect of the phosphate coating on high-strength steel would be evaluated by sustained static load test on a notched specimen.

The material used in this investigation was ⅜-in. rod conforming to Federal Specification 4340 steel. It had the following chemical composition: 0.40% C, 0.027% P, 0.015% S, 0.68% Mn, 0.23% Si, 1.80% Ni, 0.83% Cr and 0.25% Mo. Small test specimens were cut 2½ in. long and the

central portion (1½ in. long) was turned down to ¼ in. diameter. The specimens were austenitized in a salt bath at 1550° F. for 1 hr., quenched in agitated oil at 125° F. and then air cooled down to room temperature.

The specimens were divided in three lots and tempered 1 hr. at 400, 600 and 875° F., respectively, resulting in hardness of C-52 to 53, C-48 to 49 and C-41 to 42. Two of each were tested in tension, giving the results shown in Table I. In all the others a 60° V-notch, 0.0375-in. deep, was ground in the center with bottom radius 0.003 in. (Threads at ends of all specimens were also ground after heat treatment.) It will be noted that the yield strength resulting from the 400° temper (C-52.5) was *lower* than that obtained in the softer specimens after the 600° temper to C-48. The cause of this anomaly has not been investigated.

Table I – Strength of Specimens Before Phosphating

Hardness	Specimens Without Notch				Notched, Ultimate
	Ultimate	Yield	Elong.	R.A.	
C-52 to 53	295,000	208,000	13.0	37.1	320,800
	286,000	210,000	12.0	33.0	325,000
C-48 to 49	246,000	228,000	14.0	50.2	303,000
	248,000	236,000	13.0	45.6	295,000
C-41 to 42	200,000	191,800	15.0	49.4	267,000
	200,000	193,800	15.2	52.6	272,000

Table II – Sustained Loading of Phosphated Samples

Aged at 70° F.	Loaded 90%		Loaded 70%	
	Number	Life (Hr.)	Number	Life (Hr.)
C-48 to 49 Hard; 298,000 Psi. Ultimate (Notched Bars)				
0.5 hr.	4	6 to 24	4	6 to 12
3	4	7 to 16	1	50
			1	NF
5	5	6 to 12	1	324
	1	NF	1	NF
24	4	NF	—	—
C-52 to 53 Hard; 323,000 Psi. Ultimate (Notched Bars)				
0.5 hr.	4	12 to 18	2	24 to 30
			1	3618
5	1	24	—	
	1	NF		
24	2	NF	—	

NF: No fracture after 100-hr. loading.

Coatings – Heat treated (notched) specimens were phosphated in accordance with specification MIL-C-16232. Two types of coating were used, a zinc-base coating (Type I) and a manganese-base (Type II). No essential difference in the results could be found – both phosphate coatings, under the test conditions, are essentially equal.

The concentration of the zinc-base solution Type I was the standard "12 point" strength with free acid maintained at 2.0 to 2.2 points (one point is the number of ml. of 0.1 NaOH required to neutralize a known amount of solution). Iron content of the bath was 0.2 to 0.3%. The bath was operated at 205° F. for 15 min., which produced a minimum coating weight of 1500 mg. per sq.ft. Finally, the coated pieces were passivated in a hot chromic acid solution containing 7 oz. CrO_3 in 100 gal. H_2O.

The phosphating solution employed for the Type II coatings was also a proprietary bath complying with the requirements for Type II solution of MIL-C-16232. Its concentration was the standard "30 point" strength with free acid maintained at 5.0 to 5.5 points. Iron content was 0.3 to 0.4%. The bath was operated at 200 to 205° F. for 30 min. This produced a minimum coating weight of 1000 mg. per sq.ft. These coatings were passivated in the same hot chromic acid solution.

Test Ring – Notched and phosphated specimens were tested by static loading in calibrated rings until fracture occurred (or for a maximum period of 100 hr., which, for the purposes of this investigation, was established as a life test indicating no embrittlement). The load was applied to the specimen by tightening a nut on the end of the holding fixture. The change in diameter of the ring measured the load applied, in accordance with a load-deflection curve determined in advance for each test ring. The time the specimen was under load was measured by a timer connected in series with a microswitch which contacted the specimen.

Results – Several test specimens from each hardness group were aged at 220° F. for 1 hr. None of these broke in the test ring at 90% of the corresponding notched ultimate strength in the last column of Table I. It was concluded, therefore, that any embrittlement from the usual phosphate coatings could be prevented by baking 1 hr. at 220° F.

It is generally considered, also, that the cause

Burns From Atomic Bombs*

THERE ARE THREE major sources of risk to human beings unfortunate enough to be near a nuclear explosion, namely from the heat, from the blast, and from the radiation (neutrons and gamma rays).

An enormous number of neutrons are freed by either the fission or the fusion bombs, but they are absorbed very rapidly or are slowed down more gradually, producing gamma radiation in either event. Gamma rays are also produced by the radioactive decay of the fission products, some of them having very short life.

For a given unit of energy absorbed in the body, neutrons produce a greater biological damage than do gamma rays. The amount of this relative effectiveness depends upon various factors but to place gamma ray and neutron damage on a common basis, the latter should be multiplied by 1.7. (The Rem. unit, "Roentgen equivalent, man", is used.)

The total radiation dose received from the instantaneous nuclear radiations is the sum of the contribution from gamma rays and neutrons: 30-Rem. value shown in Table I represents an exposure that probably would produce no detectable damage to individuals so exposed; 300 Rem. might produce a small number of deaths; and 1000 Rem. would almost certainly cause death for all exposed individuals. This table shows that a man will not be damaged by "instantaneous" nuclear radiations from an air burst at any distance he could expect to survive the heat and blast, as will be shown later. (Note that the figures represent instantaneous effects – not safety against induced radiation in the debris or from fall-out near the explosion.)

About one third of the total energy of an air burst is represented by thermal radiation from the fire ball. The fire ball from a 20-kiloton burst (equivalent to 20,000 tons of TNT) will be about a quarter of a mile in diameter, and its surface temperature is 8000 to 10,000° C., whereas from a 10-megaton blast (a fusion bomb) the fire ball would be more than 2.5 miles across. The smaller detonations deliver their heat in about 0.1 sec., whereas the larger ones are slower, requiring on the order of 3 sec. Furthermore, the *thermal* effects of a surface shot will be less by some 40%.

Thermal radiation falling on a target may be in part absorbed, reflected or transmitted. Dark material will of course absorb more, but if a substance chars it too may become a good absorber. The absorbed heat may be transferred through clothing to the skin and produce

Table I – Miles Versus Nuclear Exposure

YIELD KILOTONS	30 REM.	300 REM.	1000 REM.
20	1.2 mi.	0.81 mi.	0.65 mi.
200	1.7	1.2	1.1
1,000	2.1	1.6	1.4
5,000	2.6	2.0	1.8
20,000	3.3	2.5	2.2

*Extracts from "Immediate Radiations From a Nuclear Deformation", a talk before the Washington Academy of Science, Nov. 15, 1956, by Gordon Dunning, Health Physicist, U.S. Atomic Energy Commission.

of embrittlement may "evaporate" in time even at room temperature. To verify this point, other groups of test specimens were aged at room temperature for varying periods of time: 0.5 hr., 3.0 hr., 5.0 hr., and 24.0 hr. After aging, the coated specimens were put into test rings and loaded either to 90% or to 70% of the ultimate strength of the notched bars (last column in Table I).

None of the specimens tempered at 875° F., C-41.5 hard and with ultimate strength in unnotched bar of 200,000 psi., broke after 100 hr. in the test ring. It was concluded, therefore, that this high-strength steel, hardened and then tempered at 875° F., could be phosphated according to Specification MIL-C-16232 without embrittlement – even without taking the precaution of subsequent baking.

However, this steel at the two higher strength levels did exhibit embrittlement, as shown in Table II, which gives time to fracture on notched specimens aged at room temperatures for different times between coating and loading. If the sustained stress is as little as 70% of the notched

contact burns. Any opaque object will eliminate the direct thermal radiation and thus produce a "shadow" both for effects on materials and the "flash burns" on the skin.

Since transmission of heat by conduction through the skin is relatively slow, the absorbed energy is principally confined to shallow depths. Therefore, the type of burn does not differ significantly from the more usual kind (first, second, and third-degree burns) and in the Japanese bombing it has been estimated that 20 to 30% of the fatal casualties were due to flash burns.

The relationship between size of air burst and distance within which third-degree burns may be expected if the skin is wholly exposed is given in the second column of Table II. Roughly one third of this total thermal energy would be expected to produce first-degree burns, and this would occur at about 160% of the indicated distances. For example, fatal burns could be expected from full exposure to heat from a 20,000-kiloton air burst even if 28 miles away; first-degree (minor) burns could be expected 44 miles away. At 28 miles the effect of total exposure to instantaneous radiation would be unimportant, yet the thermal exposure would be great enough to char completely any exposed skin and to ignite normal clothing, and the blast wave would undoubtedly destroy even reinforced concrete buildings.

Table II – Effect of Heat and Blast

Yield Kilotons	Distance,* Miles	Arrival of Blast
20	1.4	5.2 sec.
200	3.8	15
1,000	8	32
5,000	15	60
20,000	28	116

*For third-degree (fatal) burns.

Protective Measures – The most obvious protection from thermal and nuclear radiations is by shielding. Opaque nonflammable materials between the observer and the burst would eliminate flash burns. In regions of relatively high thermal flux, however, the scattered thermal rays may constitute an additional hazard requiring all-around protection.

This scattering effect is also true for gamma rays. Theoretically, it is impossible to reduce a gamma flux to zero, but the attenuation is roughly proportional to the density of the shield. About 8 in. of concrete or 12 in. of earth will reduce the gamma flux 50%. Concrete and damp earth are two materials that have reasonably good characteristics for both neutron and gamma attenuation.

There has been some consideration given to the feasibility of evasive action.

Evasive action requires time. It only requires 5½ sec. for enough thermal energy to reach a man 28 miles from a 20,000-kiloton burst to produce first-degree burns, so time for evasive action is limited. Even the more slowly moving blast wave gives little enough time, as shown in the last column of Table II.

The above evaluation is possible and desirable for planning purposes. However, in the event on an enemy attack such a deliberate and dispassionate analysis would not be possible even if the size and position of the burst were known. If an actual detonation were to occur, the best course of action would be to move first and calculate afterwards.

breaking strength of uncoated specimens, the sample will break if loaded within 30 min. of the coating treatment. On the other hand, if loading is postponed 24 hr., no fracture will occur during 100 hr. of sustained loading at a level 90% of the strength of uncoated specimens, even when heat treated to high strength and high hardness levels.

The statements in the preceding paragraph apply to notched test pieces. Sustained static loading of coated *unnotched* specimens at the two higher strength levels resulted in no fractures after 100 hr., and these specimens were held only 30 min. at room temperature after coating and were loaded to 90% of the short-time breaking strength.

(Uncoated notched specimens at all hardness levels withstood 100 hr. at 90% of the notched breaking strength, tested at standard loading rates, without fracturing.)

The over-all conclusion which can be drawn is that the embrittling effect of phosphate coatings can be prevented by either aging for 24 hr. at room temperature or 1 hr. at 220° F.

Improved Ductility in Titanium Welds

*By M. L. KOHN, G. E. FAULKNER and G. W. BAUER**

The commercial alpha-beta alloy with 6% Al and 4% V has deficient bend ductility when welded with filler metal of the same composition, but much better when welded with unalloyed titanium as filler metal, especially after a long anneal in the alpha-beta phase region. (Q5g, K9, 2-10; Ti)

TITANIUM ALLOYS of alpha-beta microstructure, despite a combination of physical and mechanical properties recommending them to airframe and jet engine manufacturers, have poor weldability in the sense that the bend ductility of joints is much lower than in the sheet metal being joined. It is therefore important to find out whether this deficiency can be cured by correct choice of filler rod or a practicable post-weld heat treatment. A commercial alloy as 0.040-in. sheet was studied; parallel tests with commercially pure titanium and an alpha alloy were used for comparison. The chemical and mechanical properties of these sheet metals are given in Table I on the opposite page.

Welding Method – Welds were made with a tungsten arc, shielded with inert gas (argon or helium). Welds in the 6-4 Al-V and 5-2.5 Al-Sn sheet were made manually in a helium-filled chamber to avoid any contamination from oxygen and nitrogen. Filler metal was a narrow strip sheared from sheet. The unalloyed titanium was welded in an automatic machine in air without filler, because it is known that the ductility of such joints is unaffected by shielded-arc welding in air rather than in a chamber filled with inert gas.

Effect of Welding – The 6-4 Al-V sheet was first welded with filler metal of the same composition. Tensile tests of the as-welded joints showed the ultimate and yield strengths to be substantially changed when tested transversely (that is with the welded joint across the specimen at right angles to the direction of stress). This was to be expected from the fact that failure was in the base metal – that is, the joint efficiency was 100%. When tested in the longitudinal direction (joint approximately along the axis of the test piece), the yield strength was unchanged, the ultimate strength was up to 136,800 psi., but the elongation in 2 in. was only 1.0%, and elongation in 1 in. was only 2.0%. (Compare values of elongation of 14 and 21% from Table I.)

Ductility was also measured by bending the

*The investigations reported in this article were performed by Messrs. Kohn and Faulkner at Battelle Memorial Institute, Columbus, Ohio, and were coordinated by Mr. Bauer, staff metallurgist for Mallory-Sharon Titanium Corp. of Warren, Ohio.

R. D. Buchheit of Battelle Memorial Institute performed the metallographic work.

Table II – Bend Ductility of Welds and Sheet

DIRECTION OF WELD	WELDS	SHEET
Crosswise		
Minimum bend radius	8.9 to 16.6 t	2.4 to 4.8 t
Elongation in outer fiber	5.3 to 2.9%	17.2 to 9.4%
Along the bend		
Minimum bend radius	11.2 to 14.4 t	4.2 to 4.8 t
Elongation in outer fiber	4.3 to 3.4%	10.6 to 9.3%

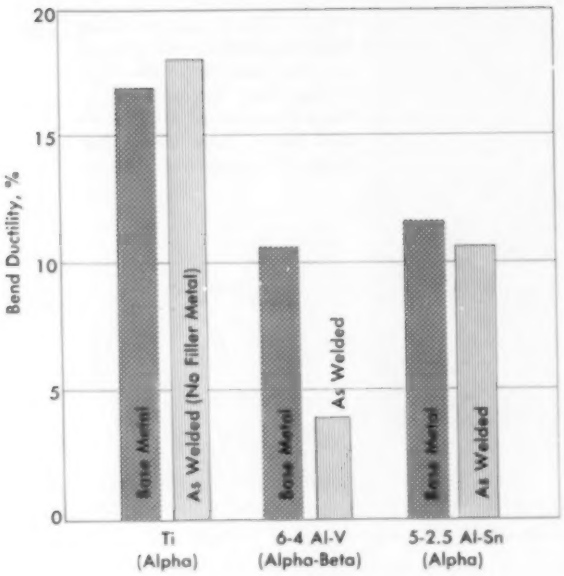


Fig. 1 – Comparison of As-Welded Joints in 0.040-In. Titanium and Alloy Sheet, Using Thin Strips of Base Metal as Filler Rod. Bend ductility is the % elongation at the outside of minimum bend without fracture.

sample and noting the minimum bend radius (the radius of the smallest die measured in terms of sheet thicknesses over which the specimen could be bent without failure) and the % elongation in the outer fiber calculated from the minimum bend radius, MBR, by the formula

$$\% \text{ Elongation} = 50 \div (\text{MBR} + 0.5)$$

Figures for bend ductility of welds and original sheets are summarized in Table II p. 82.

It is obvious from these values that the bend ductility of welded joints in 6-4 Al-V alloy is relatively low.

A comparison between the bend ductility of the above joints and those made in commercially pure titanium sheet (no filler metal) and in 5-2.5 Al-Sn sheet (with filler metal) is shown in Fig. 1. This shows that the bend ductility of 6-4 Al-V welded joints was considerably lower than that of the base metal and also than that of the other two materials as welded. Both of the alpha titaniums can be welded without much change in the bend ductilities.

Effect of Filler Metal – Two methods have generally been tried to improve the properties of welded joints: First, use a filler metal with a composition different from that of the base metal; second, use some postweld heat treatment. Both of these methods were investigated in our study of the 6-4 Al-V alloy (MST 6 Al-4 V).

As a first try, commercially pure titanium was used as a filler metal, whereupon dilution occurred in the fusion zone, producing a weld metal with a lower alloy content than the base metal. The lowered alloy content decreased the

Table I – The Sheet Metals Studied

	Commercial Ti*	6-4 Al-V†	5-2.5 Al-Sn‡
Microstructure	Alpha	Alpha-beta	Alpha
Composition			
Aluminum	—	6.0	5.0
Tin	—	—	2.5
Nitrogen	0.032	—	—
Vanadium	—	4.0	—
Longitudinal properties			
Ultimate strength	90,200	126,700	135,200
Yield strength	71,800	119,700	126,200
Elongation in 2 in.	23.0%	14.0%	19.5%
in 1 in.		21.0%	
Minimum bend radius	2.5 t	4.4 t	3.8 t
Elongation outside bend		10.0%	
Transverse properties			
Ultimate strength	90,200	127,400	
Yield strength	74,000	118,400	
Elongation in 2 in.	22.4%	16.0%	
in 1 in.		22.0%	
Minimum bend radius	2.5 t	3.9 t	
Elongation outside bend		12.0%	

*Trade designation: MST Grade III. †Trade designation: MST 6Al-4V
‡Trade designation: A-110AT

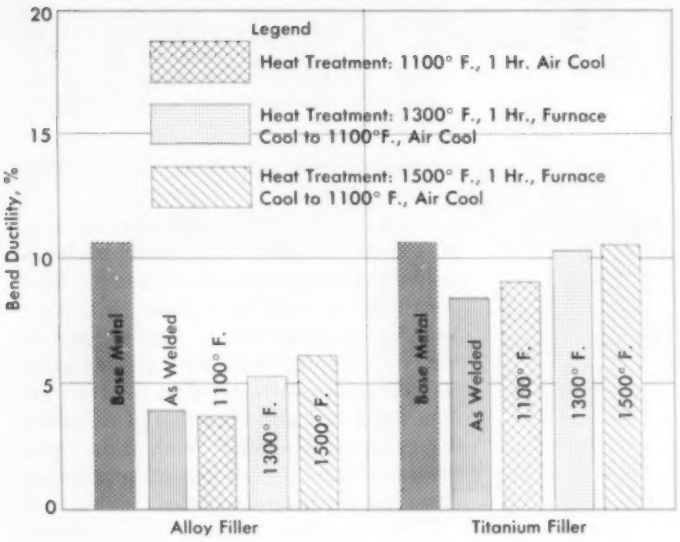


Fig. 2 – Use of Commercially Pure Titanium as Filler Metal in Tungsten Arc, Shielded Welds Does Little Harm to Bend Ductility of MST 6 Al-4 V Sheet, Especially After High-Temperature Anneal

response to heat treatment of the diluted portion of the weld, but the metallurgical characteristics of the heat-affected zone were not affected.

Tensile tests cut with the weld transverse broke at a somewhat lower unit load than the original sheet (averaging 123,900 psi. rather than 127,400 psi, as in Table I), and half of the test pieces broke in the weld metal and half of them in the base metal. When tested longitudinally the average ultimate strength (138,500 psi.) and yield strength (124,100 psi.) were about the same as when the filler metal was the same as the base metal. The tensile elogation was slightly better, being 1 to 2.5% in 2 in., 2 to 3% in 1 in., and 4 to 6% in 0.5 in.

Results of the longitudinal bend tests, in which all zones of the weld were forced to deform simultaneously, were very consistent, and the ductility ranged from 7.7 to 9.4% elongation at the outside of the bend. This was considerably greater than that of joints made with base metal for filler, and only a little less than that of the unwelded sheet (11% average). In the bend tests where the weld was transverse to the bend, the results were scattered and ranged from 5.6 to 10.9% elongation. The scatter was attributed to the difficulty of obtaining uniform strain across the weld while in the bend test.

It would appear from these figures that the use of commercially pure titanium filler metal improved the bend ductility of arc welded joints in 6-4 Al-V alloy sheet (MST 6 Al-4 V), but did not improve the tensile ductility significantly. It is difficult to explain this lack of

Fig. 3 – Transition From Base Metal Through Heat-Affected Zone to Weld Metal in 6-4 Al-V Alloy With Same Filler Metal. 70×. As Welded (not heat treated). This and other micrographs etched with 1.5% HF, 3½% HNO_3 solution and photographed by R. D. Buchheit

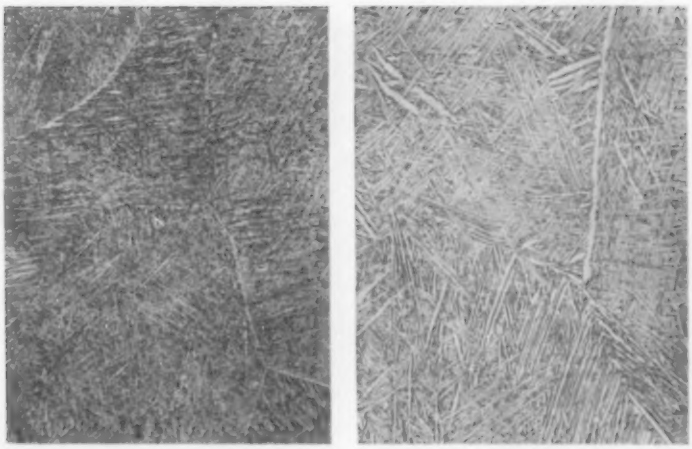


Fig. 4 – Structure of Weld Metal of Fig 3 After Annealing at 1300° F. (Left) and at 1500° F. 125 ×

correlation, except on the basis that the welded joints do not elongate uniformly. In the bend tests, only a very short length was forced to deform the maximum amount, whereas elongation over a gage length of 0.5 in. was measured in the tension tests.

We conclude, therefore, that commercially pure titanium should be used as filler material for welding MST 6 Al-4 V. The advantages might be increased or lessened by the joint designs and the thicknesses of the sheet in the weldment. For applications where welds made in base metal as filler metal do not meet specifications, commercially pure titanium for filler metal should be considered.

Postweld Heat Treatment

Three heat treatments within the alpha-beta phase field were selected to study the extent to which they would improve the ductility of arc welded joints in 6-4 Al-V alloy:

1. Heat weldment to 1100° F., hold 1 hr. and air cool.
2. Heat weldment to 1300° F., hold 1 hr., furnace cool to 1100° F. and air cool.
3. Heat weldment to 1500° F., hold 1 hr., furnace cool to 1100° F. and air cool.

The theory behind such postweld annealings is that the loss of ductility in alpha-beta titanium alloys after welding is due to the fact that the fusion zone and portions of the heat-affected base metal are cooled from temperatures in the beta field too rapidly for enough alpha to form to reach equilibrium. The resulting structures depend primarily on alloy content and cooling rate, but they are usually harder and less ductile than when equilibrium is approached, as during slow cooling.

The purpose of postweld heat treatment is, therefore, to allow time for the transformation of metastable beta crystals. The degree to which stable equilibrium can be approached will depend on the temperature and time and can be indicated by the amount of softening and the increase in ductility in the weld joint.

Figure 2 summarizes the figures for bend ductility of MST 6 Al-4 V joints, welded with either a strip of base material as filler or with commercially pure titanium, and then heat treated by one of the three cycles listed above. The gain in ductility was greatest for the heat treatment which had the highest holding temperature (1500° F.). After this heat treatment, the bend ductility of the welds made with commercially pure filler metals was almost as high as the base metal; welds made with 6-4 Al-V filler were only about half as ductile.

The heat treatments listed are not necessarily the optimum. Our results do, however, indicate that weld joints may be benefited by some combination of heat treating temperatures and holding times. The temperatures used in this study may be too high for production practice; additional information on lower temperatures and longer holding times would be valuable.

Microstructure – Hardness and ductility of the welds may be correlated with the microstructure. Figure 3 shows the typical fine-grained equiaxed structure of the base metal and the martensitic structure common to both the heat affected zone and the weld metal in as-welded joints.

After heat treatment, additional transformation of beta to alpha was observed, especially after annealing at 1300 and 1500° F. (Fig. 4), as

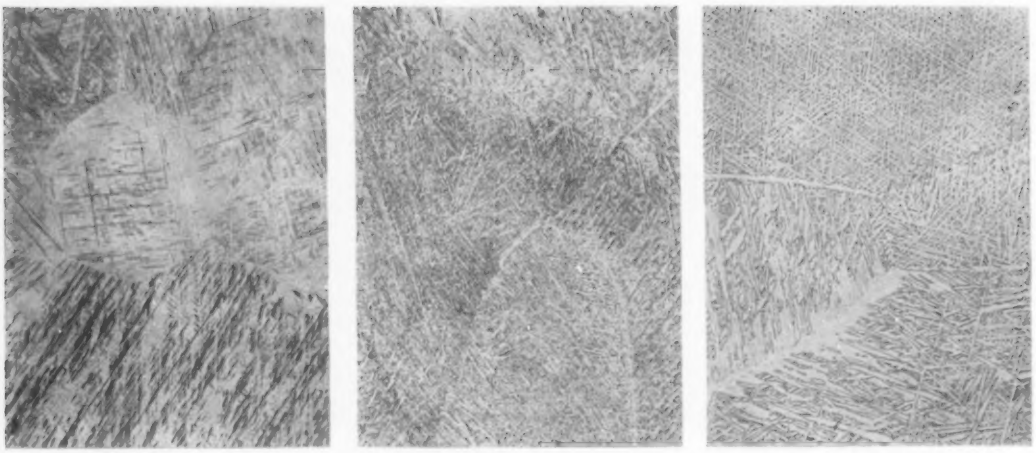


Fig. 5 – Commercially Pure Titanium as Filler Metal in Welds in Alpha-Beta Sheet Produces a Metastable Structure (Left) Which Develops Well-Defined Martensitic Appearance After Annealing at 1300° F. (Center) and 1500° F. (Right). 125 ×

Table III – Spot Weld Tests

	6-4 Al-V		Commercial Ti	5-2.5 Al-Sn
Heat	54%	58%	55%	58%
Time, cycles	5	6	5	6
Spot diameter	0.18 in.	0.22 in.	0.20 in.	0.24 in.
Nugget size	4.5 t	5.4 t	5.0 t	6.0 t
Average tension-shear strength	1724 lb.	2128 lb.	2016 lb.	2463 lb.
Average cross-tension strength	507 lb.	506 lb.	554 lb.	550 lb.
Tension-to-shear ratio	0.29	0.23	0.27	0.22

indicated by the increasing amounts of alpha platelets and the coarsening of existing ones. Orientation of the platelets was not affected.

Photomicrographs of weld metal in joints made with commercially pure titanium as a filler metal (Fig. 5) show similar trends.

Properties of Spot Welded Joints

The properties of spot welded joints in the three alloys listed in Table I also were determined and compared. Welds were made in a 200-kva., three-phase, series-connected Sciaky spot welder. Electrodes had 3-in. spherical ends; pressure was 750 lb. Time and current were adjusted to produce nuggets whose diameters were about five times the thickness of the sheet. This was not always produced, and because the nugget diameter has a significant effect on the shear strength of spot welds, these slight variations should be taken into consideration in comparing the three materials. Results are shown in Table III.

On the basis of the tension-shear strength, spot welds in the three materials were similar. The shear strengths were very consistent and are believed to be satisfactory for most applications. The cross-tension strengths of spot welds in the three materials also were similar, but tended to be about 10% lower for MST 6 Al-4 V than for the other two metals.

Conclusions

The suitability of MST 6 Al-4V for arc welding applications depends on the properties required of the welded joint. If low ductility (4% bend elongation) can be tolerated, the alloy would be suitable for welding with tungsten arc, helium shielded. For higher ductility, commercially pure titanium filler metal, postweld heat treatment, or a combination of these could be used.

The MST 6 Al-4 V alloy appeared to be satisfactory for many applications. The properties of spot welds are influenced considerably by welding conditions and sheet thickness. Therefore, spot welds should be evaluated for each potential application.

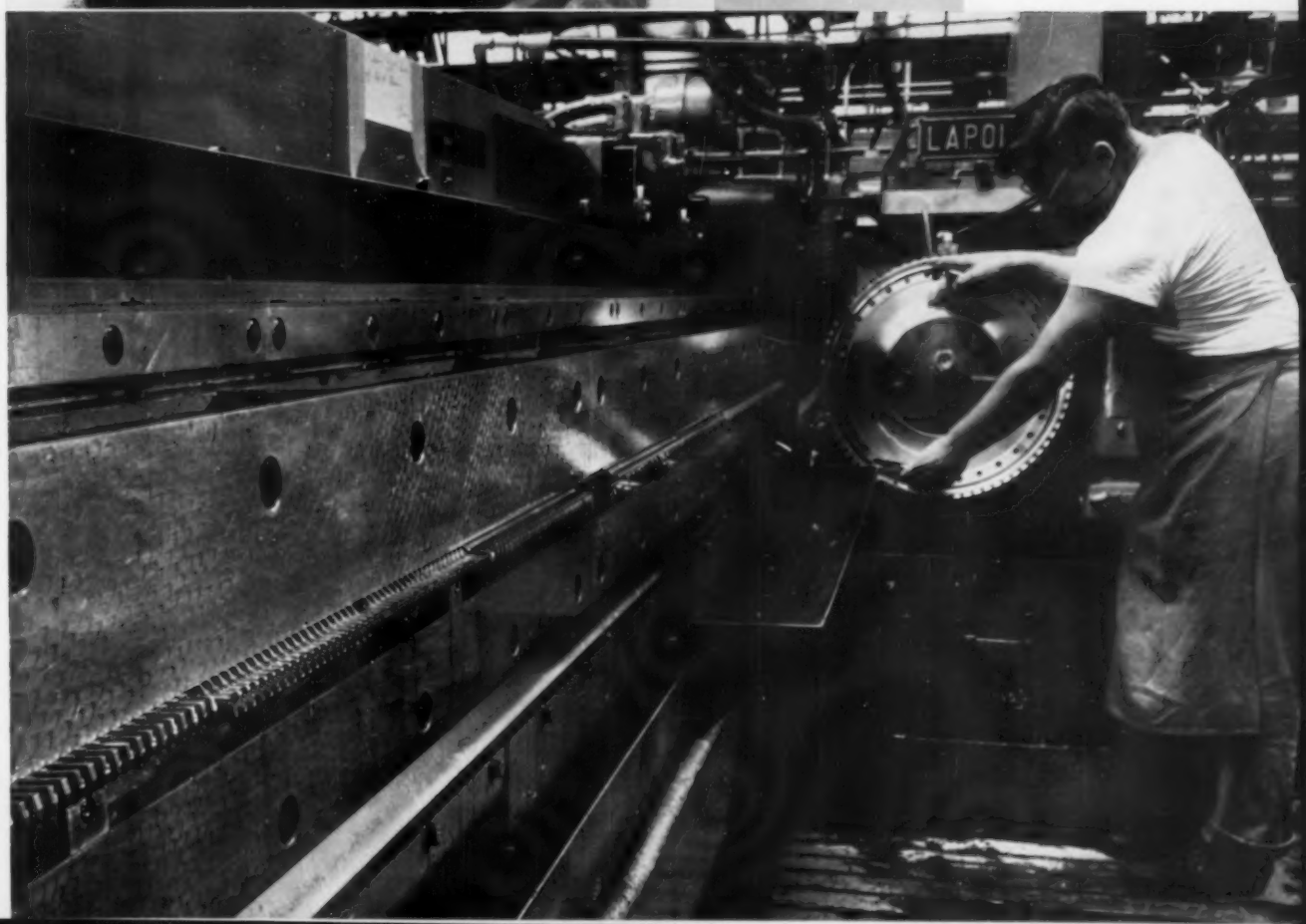
Shaping of a Disk

A PRATT & WHITNEY AIRCRAFT jet engine compressor is checked at the East Hartford, Conn. plant of the aircraft engine manufacturer. A jet engine compressor is essentially a series of disks or bladed fans which turn at a high speed and draw in huge quantities of air.

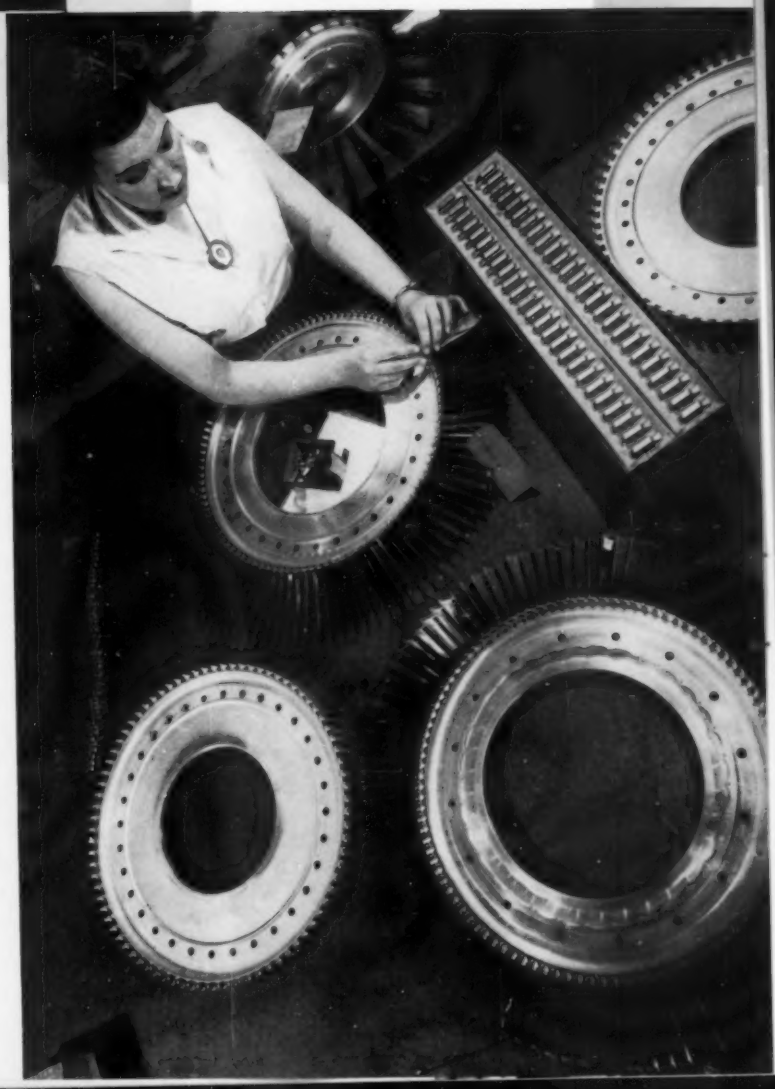
Looking like Christmas tinsel, the metal's skin is peeled from the disk; periodically the amount removed is checked with an accurate gage. The modern jet engine is the product of many skills, but essentially the art that shapes it comes from metalworking.

The sharp teeth of a horizontal broach cut slots in the edge of the disk. Later, compressor blades will be fitted into these slots to form the complete disk and blade unit. Thirty-three distinct machining operations are required in the evolution of each jet engine disk from a rough forging to the finished part.

Here a drill press is beveling the edges of bolt holes in this machining step which all metalworkers will recognize as chamfering. Through the ages none of man's arts and sciences has so steadily engrossed him as his work with metal.



Compressor blades are carefully checked for weight and balance. They must have ability to withstand tremendous stresses. The aircraft industry's manufacturing skills have been sifted from generations of metalworking. The trend continues toward more complete and highly perfected tooling and methods of manufacture to meet the demands of the advanced designs of aircraft, their engines, and their equipment.



Each compressor blade must be placed according to proper sequence and weight. Nearly half of Pratt & Whitney Aircraft's current compressor production now has disks made from titanium, the light metal whose fabrication processes have been pioneered by the division. Often called the heart of the jet, the compressor is made up of a varying number of bladed disks depending upon the turbine's configuration. Man's modern skill in working a multitude of metals is as important in the Jet Age as it was in his progress through the Bronze Age and the Iron Age.

Book Review

A Comprehensive View of the Oxidation of Metals

*Reviewed by M. SIMNAD**

OXIDATION OF METALS AND ALLOYS, by O Kubaschewski and B. E. Hopkins, Academic Press Inc., New York, 239 p., $6.00.

THE TENDENCY toward specialization among research workers is often decried, but the facetious remark that a specialist is one who knows more and more about less and less until he knows everything about nothing, can be challenged by most scientists who find it essential to keep abreast of advances in many fields of knowledge besides their own. This is especially so in metallurgy, where familiarity with progress in physics, chemistry and engineering is called for. A case in point is the oxidation of metals and alloys, which is of great theoretical interest as well as of wide practical importance. Work on oxidation is related to such diverse fields as solid-state physics, diffusion, chemical kinetics, crystallography, electrochemistry and a host of others.

In recent years the term "oxidation" has been generalized to include all metal-surface reactions resulting in the formation of surface films, such as oxides, nitrides, iodides and sulphides. The complex interaction of metals with gases is governed mainly by the nature of the reaction products formed on the metal surfaces. Accurate quantitative descriptions of these reactions in the past two decades were greatly assisted by the theoretical contributions of Wagner and of Mott. These theories have been confirmed and extended, thanks to recent accurate measurements of oxidation rates under rigorously defined conditions. Besides the outstanding series of papers by Gulbransen, much other work has been published and a decided need has risen for a comprehensive work on the subject. Kubaschewski and Hopkins have written a most important and timely book which will be found useful by a wide audience. They have skillfully assembled the pertinent scientific and technical data, so that the problem may be seen and understood as a whole.

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The book is divided into four main sections. The first section furnishes basic information — namely, a summary of fundamental data on the metals and their oxides and nitrides; diffusion and electrical conductivity in surface films (which are the usual rate-controlling factors in oxidation); and the rate laws which govern the oxidation process and the influence of temperature, pressure, crystal structure and physical form of the oxides.

In the second section the experimental methods employed in oxidation studies are described. These include considerations of the purity of the metals and their surface conditions and of the nature of the gaseous atmosphere. The methods available for examination of the oxidation product are listed and the techniques for measurement of oxidation rates are given in some detail.

The third section describes the mechanisms of oxidation. A careful distinction is made between the phenomena involved during the first stages of oxidation and those that apply after a certain film thickness has been reached. This difference is often a source of confusion to those who are not familiar with the different processes involved during the thickening of oxide films. Wagner's theory of parabolic oxidation — which covers the later stages where film growth is a diffusion-controlled process — and Mott's elaborate theory of thin film formation are dealt with.

The basic postulate of Wagner's theory is to the effect that the rate-determining factor in oxidation is the diffusion of ions in the oxide lattice; the oxide lattice is known to contain defects and concentration gradients down which the ions can migrate. Although the authors give precedence to the special form of derivation of Wagner's equation by Hoar and Price and by Jost, who use the simple analogy of the flow of current through a cell, the actual derivation given by Wagner himself cannot be neglected. Wagner not only relates the rational rate con-

stant to the electrochemical properties of the oxide, but also formulates an equation which involves the self-diffusion coefficients of the ions and cations. For completeness, the authors should have included this derivation too, since there is an increasing trend toward measuring the self-diffusion coefficients of the ions in surface films.

The authors give several examples of the practical applications of Wagner's theory, and summarize their conclusions concerning the effects of elements on the oxidation rate of a metal as follows:

"1. The oxidation rates of metals forming oxidation layers consisting of metal-excess semiconductors can be decreased by adding metals of higher valency than that of the basis metal.

"2. The oxidation rates of metals forming oxidation layers consisting of metal-deficit semiconductors can be decreased by adding metals of lower valency than that of the basis metal.

"3. The oxidation rates of metals forming oxidation layers consisting of pure cationic conductors can be decreased by adding metals of higher valency than that of the basis metal."

Several oxide layers can be present on a metal whenever conditions are suitable for the metal to form stable compounds with the gas. The compound with the higher metal content will be nearest the metal surface. The relative thickness of the separate layers will depend mainly on the diffusion rates through the layers and on the differences of chemical potentials at the interfaces. The relative rates of growth of the different layers, the mechanisms by which they grow, their volume relationships, and their ranges of stability have to be taken into consideration. For example, Gulbransen has recently discovered the remarkable fact that FeO, which is unstable below 1060° F. in the bulk phase, can be detected down to 750° F. when present as a thin film on iron. Our understanding of the formation of several oxides on a metal has been greatly advanced, since the publication of this book, by the work of Himmel, Mehl and Birchenall. They have measured the rates of self-diffusion of iron oxides of various compositions. These data were applied to calculate the rates of oxidation of iron and its oxides, using the theoretical rate equations developed by Wagner. The results were found to be consistent with the experimental rate constants and with the transport mechanisms in the oxides of iron previously proposed by Davies, Simnad and Birchenall.

The oxidation of alloys is complicated by the presence of "secondary effects", such as the different relative rates of attack on the alloy components, the nature of the mixed oxides formed, the formation of cracks due to stresses in the oxide layer, and the effect of subscale formation. The phenomenon of internal oxidation, or subscale formation, has been observed in many alloy systems. An expression for the rate of growth of such layers has been derived by Rhines, Johnson and Anderson, which corresponds to a parabolic growth and agrees well with experimental results. The interesting recent work of Thomas on the oxidation of alloys of noble metals with copper is included. Wagner's theory of alloy oxidation is also discussed.

The final section of the book is a systematic presentation of experimental results reported in the literature. The authors do well to point out that a given metal may actually have three temperature ranges, in each of which a different time relationship governs oxidation — a fact often ignored. It is also well to remember that much of the work on "pure" metals reviewed in this book was carried out at a time when the impurity levels were high by modern standards. More recent studies with ultra-pure metals indicate that some of this work will have to be repeated to obtain accurate data.

The information on the oxidation of alloys is highly selective. The influence of systematic additions of various elements to one metal at a time are reported wherever possible, and this serves as a useful guide for selecting oxidation resistant alloys of a given metal.

This book deals mainly with high-temperature oxidation, although mention is made of work on the formation of oxide films on several metals at room temperature and at low temperature. The controversy, instigated by Uhlig, over the nature of the interaction between metals and gases at low temperatures, has stimulated interest in this field, and the development of extremely sensitive experimental techniques for studying the thin films formed at low temperature has enabled several workers to make valuable contributions to the subject.

Advances in oxidation theory and the development of oxidation resistant alloys will have direct repercussions upon our understanding and control of corrosion and protection of metals and alloys. The reviewer agrees with Dr. Vernon's foreword to the effect that this book "will appeal strongly both to those more immediately concerned with the fundamental aspects of oxidation, and those interested in the practical application of scientific principles."

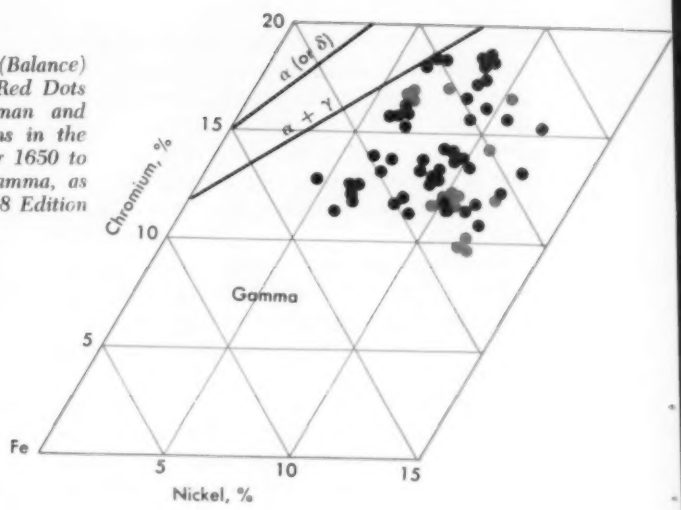

Fig. 1 – Chromium, Nickel and Iron (Balance) in the 49 Melts Are Shown in Black; Red Dots Represent Alloys Studied by Eichelman and Hull. Phase fields represent conditions in the temperature range (900 to 1300° C., or 1650 to 2400° F.) for maximum amount of gamma, as shown on p. 1261 of Handbook, 1948 Edition

A new attempt at a linear relationship between M_s temperature and composition in nickel-bearing stainless steels has been made which shows a small improvement over a formerly published equation. Because of the complex interactions of alloying elements, further improvement by first-order equations is not to be expected. (N8p, 1-4; SS)

Computation of M_S for Stainless Steels

*By F. C. MONKMAN, FRANK B. CUFF, JR., and N. J. GRANT**

A SERIES OF INVESTIGATIONS, sponsored by the Office of Naval Research, has been under way at Massachusetts Institute of Technology on stainless and heat resistant steels. The general objective is to relate the chemical composition and microstructure to the high-temperature strength, creep resistance and creep-rupture properties. It is the belief that, when these relationships are accurately known, a suitable material with minimum amount of alloy can be chosen for a given set of service requirements.

It has long been known that the formation of martensitic ferrite in stainless steels has a pronounced effect on the mechanical properties and corrosion resistance. In addition, the appearance of martensite in the austenitic structure at elevated temperatures and its stability have an important bearing on both the structure and the strength of an alloy at elevated temperatures. For that reason, and in line with the main objectives stated above, it was decided to determine as accurately as possible the M_s temperature of a rather wide range of laboratory heats, and to see how they compared with temperatures calculated from the equation suggested by G. H. Eichelman, Jr. and F. C. Hull in *Transactions*, , Vol. 45, 1953, p. 77.

The alloys for this program were melted in a small carbon-arc furnace from ingot iron, electrolytic nickel and ferrochromium, and were deoxidized with a calcium-manganese-silicon alloy. Since the martensite temperatures were to be determined by electrical resistivity measurements, suitable samples were sucked up in Vycor tubes from the melt.

These rods were successively cold swaged and homogenized at 2000° F. in a helium atmosphere to break up the cast structure. The eventual grain size varied between A.S.T.M. No. 3 and No. 6.

The amounts of iron, chromium, and nickel in the 49 melts are presented graphically in Fig. 1. Carbon plus nitrogen varied from 0.035 to 0.176%, as determined from double or triple-

*Dr. Monkman is Research Director of Walworth Co., Boston; Dr. Cuff is Assistant Professor, and Dr. Grant is Professor in the Department of Metallurgy, Massachusetts Institute of Technology, Cambridge.

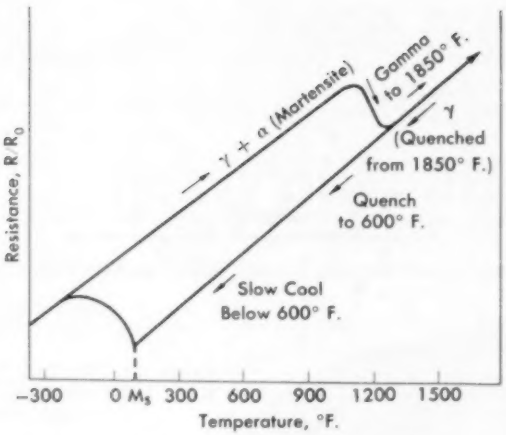

Fig. 2 – Resistance Versus Temperature Curve for a Typical Stainless Steel, Showing Solution of Martensite on Heating at about 1100° F. and a Sharp M$_s$ Point at +80° F. on Cooling

check analyses. The nitrogen value from a wet analysis was checked by a vacuum fusion analysis. Silicon contents varied from 0.05 to 0.29%. Manganese was quite low in all alloys, ranging from 0.03 to 0.13%. In these respects our alloys were quite different from the 21 laboratory heats studied by Eichelman and Hull; in the latter the silicon ranged from 0.33 to 2.58 and the manganese from 0.63 to 5.03%.

Prior to starting the test each specimen was held 30 min. at 1850° F. to dissolve any martensite or carbides. As shown by the phase boundary in Fig. 1, all the alloys should then have been completely austenitic, although subsequently some specimens were rejected because they contained delta ferrite or were severely segregated. The specimen was then rapidly cooled through the carbide precipitation range and electric resistivity was measured while it cooled from about 600° F. to −320° F. Chilling below room temperature was done in a double-walled Pyrex tube surrounded by liquid nitrogen; the cooling rate was about 15° F. per min.

Several of the samples were heated in a high-temperature X-ray camera, and diffraction patterns were made to identify the phases present and to correlate them with changes in resistance. After testing, each sample was examined metallographically to determine the phases present and the grain size.

Figure 2 shows a typical resistivity curve during heating and cooling one of the alloys. (Phases determined by X-ray diffraction are also shown.) Decomposition of martensite and solution of ferrite during heating is accompanied by a decrease in resistance at about 1100° F.

The M$_s$ temperature is defined as that temperature during cooling at which the initial increase in resistivity is first observed. In this particular alloy M$_s$ = + 80° F. Resistivity measurements identify the M$_s$ temperature quickly and simply, and we feel that this method is much more exact than the dilatometric method used by Eichelman and Hull.

The steels studied at Massachusetts Institute of Technology were made with silicon and manganese as low as practicable in order to limit the variables to chromium, nickel, and carbon plus nitrogen. (Both silicon and manganese are potent stabilizers of austenite.) M$_s$, as found experimentally, varied from 500° F. for a 12.8% Cr, 4.5% Ni, 0.115% C + N alloy to −250° F. for a 17.2% Cr, 8.2% Ni, 0.151% C + N alloy. It was assumed that a linear relationship existed between composition and M$_s$ temperature, and that the effects of small amounts of silicon, manganese and trace elements could be neglected. On this basis the constants and coefficients for the equation were determined by the method of least squares in a digital computor:

$$M_s = 2160 - 66(\%\ Cr) - 102(\%\ Ni) - 2620(\%\ C + N) \quad (1)$$

For comparison purposes, Eichelman and Hull's equation is

$$M_s = 75(14.6 - Cr) + 110(8.9 - Ni) + 3000[0.068 - (C+N)] + 60(1.33 - Mn + 50(0.47 - Si)$$

and the nickel equivalents of the other elements are Si=0.45, Mn=0.55, Cr=0.068, C=27 and N=27.

Transforming the longer equation into the form of equation (1) and using the average values of 0.08% Mn and 0.13% Si contained in our alloys, we get the following equation based on the dilatometric results of Eichelman and Hull:

$$M_s = 2277 - 75(\%\ Cr) - 110(\%\ Ni) - 3000(\%\ C + N) \quad (2)$$

M$_s$ was computed for our 49 alloys by both equations (1) and (2). Agreement was poor. Calculated M$_s$ by equation (1) missed the point as measured by electrical resistivity by 63° F., on the average. The miss by equation (2) was 66° F., on the average. Likewise Eichelman and Hull's alloys were computed and the difference from their observed M$_s$ values was 31° F. on the average by equation (1) and 37° F. when using equation (2).

There are several reasons contributing to the slightly improved values in equation (1):

1. The large change in resistance accompanying martensite formation, as compared to the

relatively small volume change, permits a more exact determination of the M_s temperature by electrometric rather than dilatometric methods.

2. A wider composition range and a better alloy distribution was covered.

3. Equation (1) was determined from 49 M_s measurements while equation (2) was based on 21 measurements.

4. Coefficients for equation (1) were obtained by the method of least squares, while those for equation (2) were determined graphically from two-dimensional plots. The whole 49 measurements could be utilized in the first-mentioned procedure in contrast to only a portion of the 21 measurements in the latter.

In spite of the above, the error between the calculated and the measured M_s for the alloys in the investigation now being reported was almost twice as large as the corresponding error for Eichelman and Hull's alloys, regardless of which equation was used. It is improbable that this large difference can be attributed to a larger experimental error.

This leads one to question the primary assumptions *(a)* that there is a linear relation between M_s and composition – that is, that the effect of each element on M_s varies proportionately with its amount – and *(b)* that the effect of each element is additive, and *(c)* that it is independent of the effects of the other elements.

All three assumptions are, of course, open to question. In fact, Morris Cohen and Clarence Zener, on the basis of free energy calculations, have both shown that the M_s temperatures vary as a non-linear function of carbon content in medium-alloy steels having less than 0.2% C.

An attempt to analyze the available information to fit a more generalized equation was unsuccessful, probably because there were not enough data to determine the required ten coefficients.

We therefore approached the problem by graphics. Since there are four variables – M_s, % Cr, % Ni, % (C+N) – and only three dimensions available for plotting, one of the compositional variables was corrected to a base value, and the measured M_s temperature was then plotted as a function of the other two compositional variables. It was found that the assumption of linearity with respect to chromium and nickel was valid throughout the chemical range investigated. That is, the coefficients in an equation relating these two elements to the M_s temperature were reasonably constant and independent of each other and of the C + N.

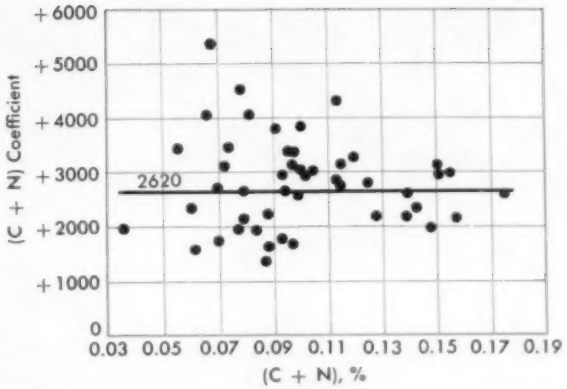

Fig. 3 – Calculated Coefficients for (C+N) Plotted as a Function of the Amounts Contained in 49 Alloys

On the other hand, the effect of carbon and nitrogen on M_s was non-linear and found to depend in a fairly complex way on the entire analysis – Cr, Ni, C, N. For example, equation (1) may be simply transposed into the following expression:

$$\text{Coefficient for C+N} = \frac{2160 - 66(\%\,\text{Cr}) - 102(\%\,\text{Ni})}{\%\,(\text{C+N})}$$

Figure 3 shows the value for this coefficient as computed for each of our 49 alloys. The value of 2620, as obtained by the method of least squares, is marked as a horizontal line on this plot. The variation of the individual points is considerable and difficult to interpret.

Since the assumption of linearity is not valid, the fit of a *linear* equation to experimental data should become increasingly inaccurate as the range, number and distribution of the experimental data increase. This would then explain the greater error encountered in calculating the M_s temperatures of the 49 alloys in this investigation as compared to the error for the 21 alloys studied by Eichelman and Hull.

In conclusion it may be stated that first-degree formulas relating M_s to chemical composition of the chromium-nickel stainless steels are inherently inaccurate, since the influence of carbon and nitrogen on the martensite point on cooling is quite complex – non-linear – and depends on the whole chemical analysis in a way as yet unknown. However, such equations should have some practical utility in predicting the M_s temperatures in a wide range of stainless chromium-nickel-iron compositions.

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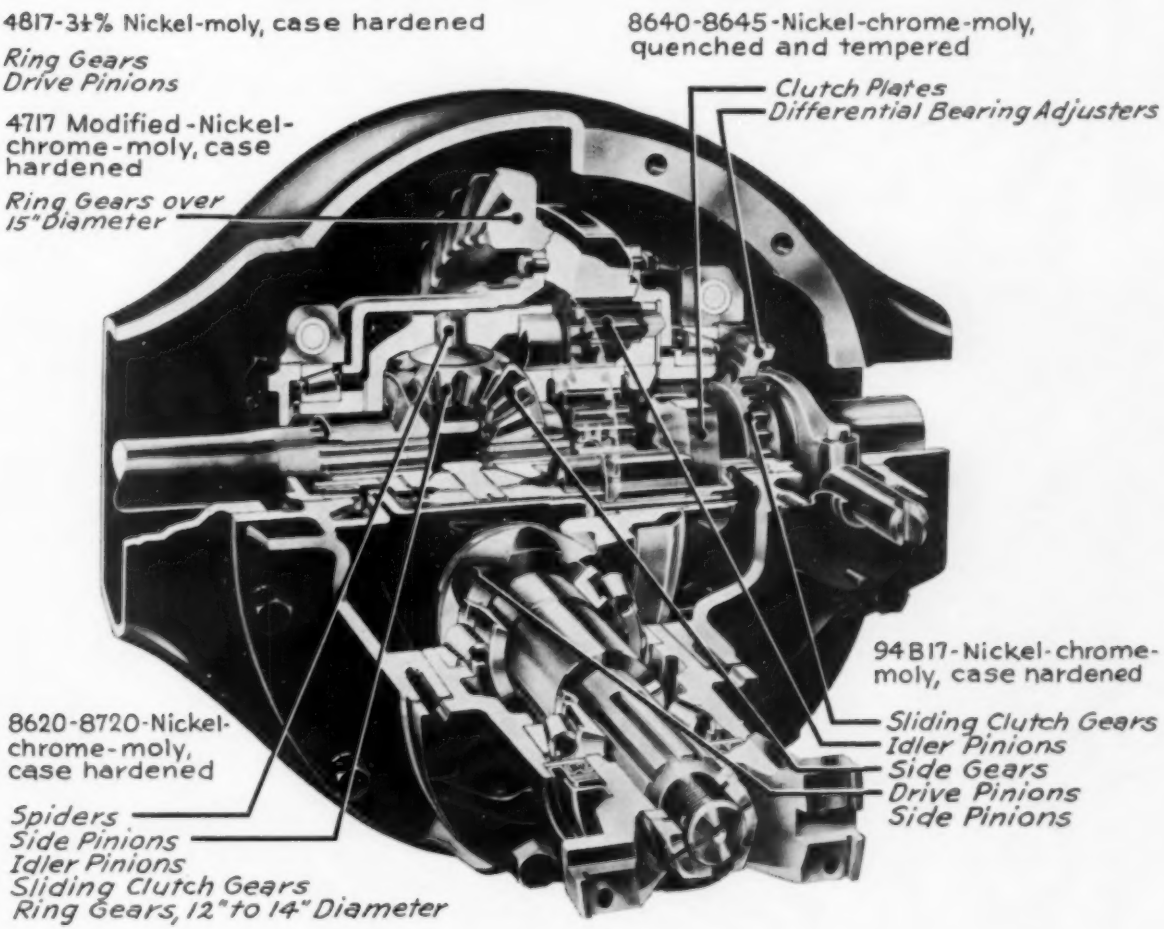

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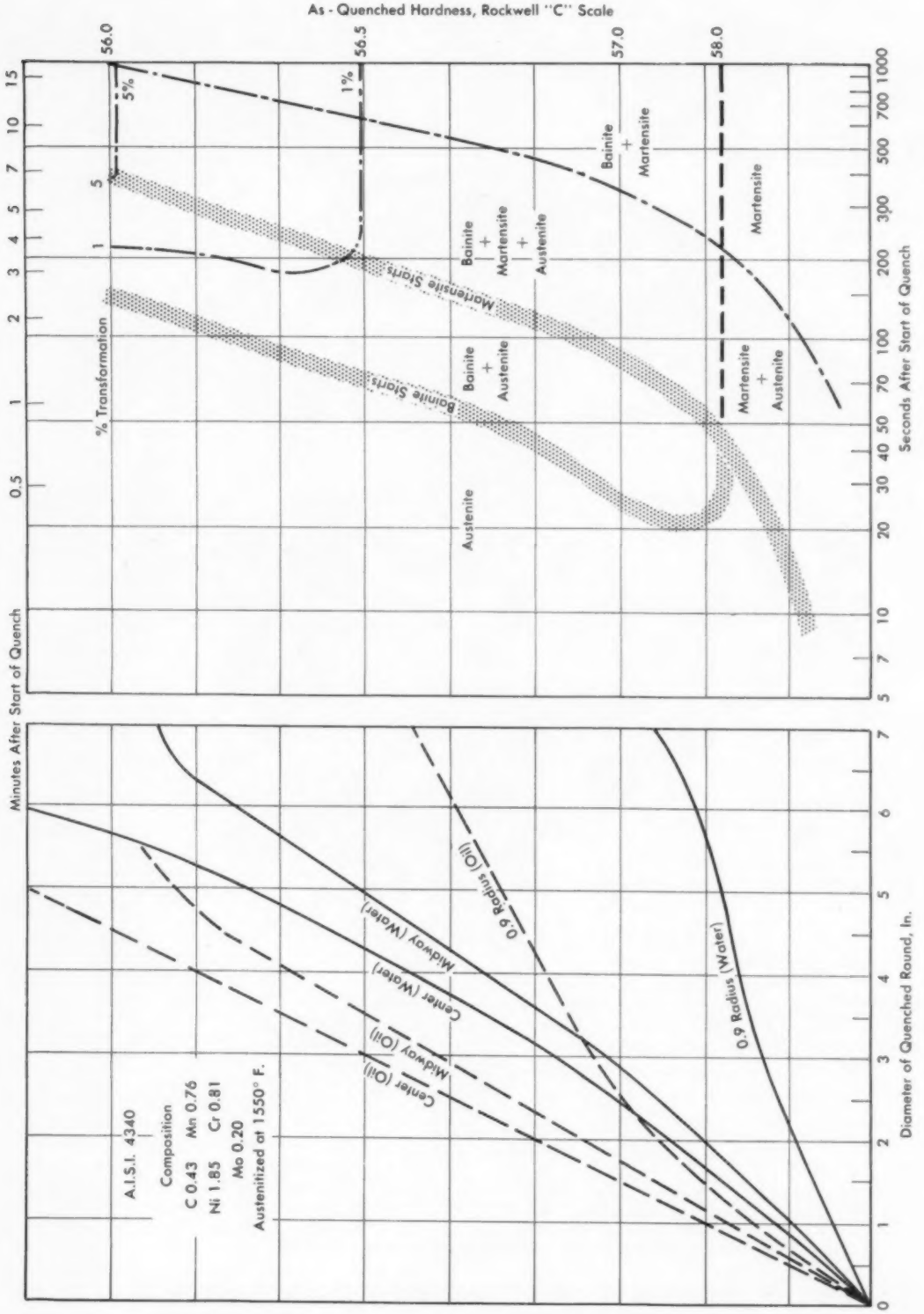
By D. J. Blickwede and R. C. Hess



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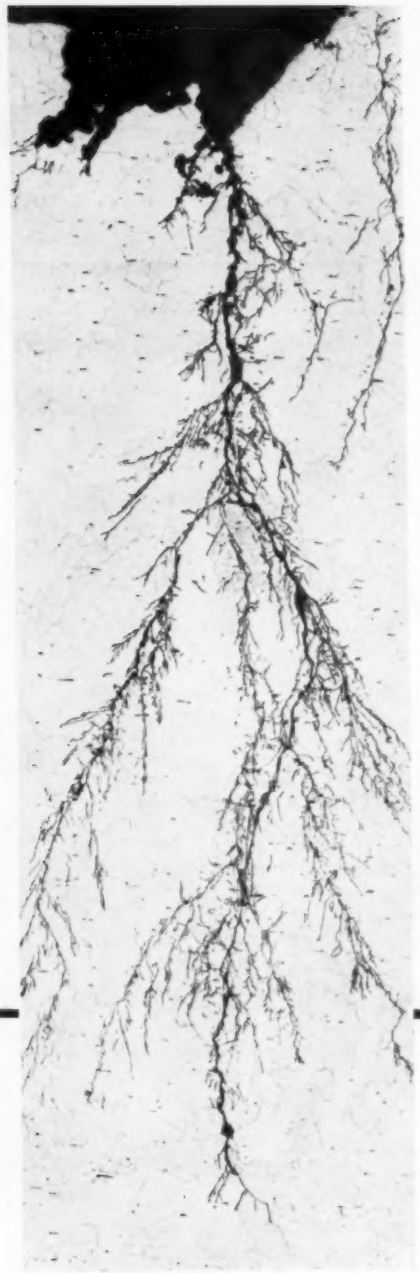

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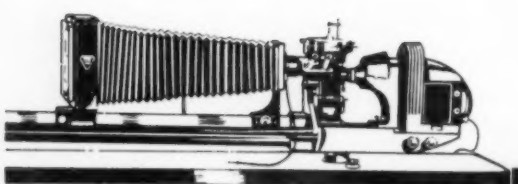

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Furnace Atmosphere Analyzers

*By WAYNE L. BESSELMAN**

Rugged and precise equipment is now available for continuous measurement, recording and control of dew point, content of specific gases, total combustibles, and specific gravity of prepared furnace atmospheres. (X7, X22, J2k, 1-2)

IT IS UNIVERSALLY AGREED that the precise and continuous measurement and control of temperature is a fundamental prerequisite of high quality in metallurgical operations in everyday practice all over the world. The continuous temperature recorders and controllers so commonly accepted today originated in 1912 with the invention and development by Morris E. Leeds of the null-balance recorder using a thermocouple as a primary element. Prior to this the heat treater could only make spot checks of temperature by the various indicators then available.

We are now in a similar transition period with respect to the measurement and control of furnace atmospheres. Since specifications and metallurgical requirements have become so rigid, spot checks of atmosphere quality by various indicating devices are no longer considered adequate.

In their papers preceding this one in the I.H.E.A.-A.S.M. conferences (printed in *Metal Progress* in the February and March issues), Messrs. Vaughan and Peck have described the close relationship between composition of the protective atmosphere, its temperature, and the reactions – or lack of reaction – with the hot steel. The influence of atmosphere quality is often even more vital to the metallurgical properties of the finished part than the temperature of heat treatment. It becomes obvious that atmospheres must be positively measured and controlled to insure reproducibility of day-to-day results.

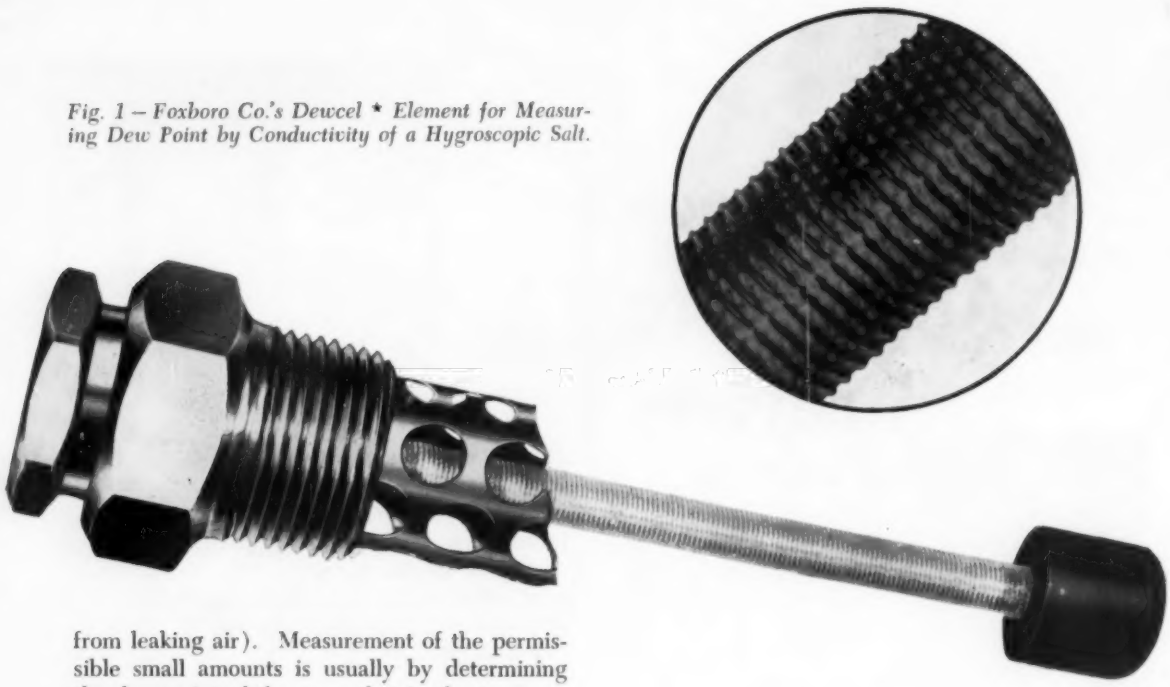
Fortunately, there have been many recent technical advances in the required instrumentation. Various analyzers can now produce a suitable output signal that can be continuously recorded or indicated and used for controlling purposes. The analyzers currently available and their principles of operation will now be briefly described.

Dew Point Analyzers

The former speakers have emphasized the reactivity of hot water vapor on hot steel surfaces. A large amount of the H_2O produced in the manufacture of the protective gas must be removed before it gets into the furnace chamber, and effective means provided which will prevent the formation of H_2O *within* the furnace (as

*Leeds and Northrup Co., Philadelphia. A paper, slightly abridged, prepared for presentation at I.H.E.A.-A.S.M. joint session on furnace atmospheres, held at National Metal Congress and Exposition in Cleveland, Oct. 9, 1956. The author emphasizes that this is a joint effort of the Industrial Heating Equipment Assoc., from the following members: Bailey Meter Co., Foxboro Co., Ipsen Industries, Inc., Leeds and Northrup Co., Lindberg Engineering Co., Mine Safety Appliance Co., Surface Combustion Corp. and Ranarex Div., Permutit Co.

*Fig. 1 – Foxboro Co.'s Dewcel * Element for Measuring Dew Point by Conductivity of a Hygroscopic Salt.*



from leaking air). Measurement of the permissible small amounts is usually by determining the dew point of the gas – that is, the temperature of saturation, where liquid water starts to form.

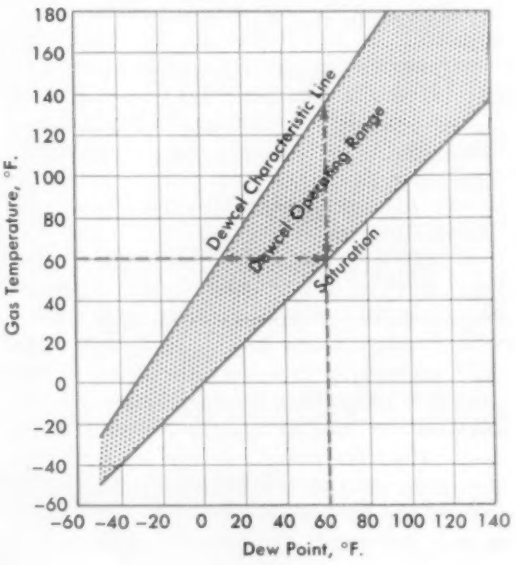
To measure this temperature, dew point analyzers are available which use one of four following principles:

1. Change in conductivity of hygroscopic salt compounds.
2. Condensation of water on cooled surfaces.
3. Formation of fog by sudden expansion of compressed gas.
4. Electrolysis of salt compounds or organic liquids.

Conductivity Change – This method or principle depends upon the behavior of a moist hygroscopic salt. If dry lithium chloride, for example, is exposed to water vapor, it will absorb moisture and dissolve to form a staturated solution. If this is then warmed, some of the water evaporates until the escaping tendency of the water is equal to the tendency of the salt to take on water. At this point of equilibrium the temperature of the salt and the saturated solution is a measure of the partial pressure of the water vapor in the surrounding gas – in other words, of the dew point.

The primary element in this instrument consists of a temperature sensing device mounted inside a thin-walled metal tube covered with a woven glass tape impregnated with lithium chloride (Fig. 1). The tube is also wound with a pair of silver or gold wires covered with a perforated metal guard. When the salt absorbs moisture from the surrounding gas, it becomes an electrical conductor. Current then passes through the salt from the adjacent pair of wires and raises the temperature until equilibrium is reached. This temperature is measured by the sensing device inside the tube, and it can be calibrated to represent the dew point of the atmosphere. The accuracy of the equipment

Fig. 2 – Operating Range for Foxboro Dewcel Depends on the Temperature of the Gas Being Drawn Through the Instrument



*Registered Trademark.

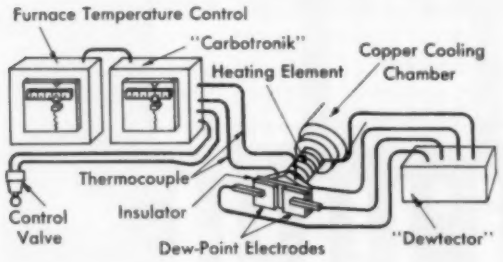
can be no higher than the absolute accuracy of the temperature-sensing device.

Since the operation of this device depends upon the conductivity of a salt solution, it will register only if the temperature of the salt is at or below the equilibrium temperature and the salt is moist. The ambient temperature of the cell thus determines the range of dew points which can be measured and Fig. 2 shows this. For example, if the ambient temperature of the gas is 60° F., dew points can be measured from 60° F. down to 10° F. If, however, the ambient were 80° F., operating range would be from 80° F. to 22° F. The "Dewcel Characteristic Line" in Fig. 2 also shows the temperature of the dew cell for any given dew point. For example, at a dew point of 10° F. the equilibrium temperature of the Dewcell would be 62.5° F.

Since the desired dew points for most generators and furnaces are on the low side of the band in Fig. 2, and the ambient gas temperatures are on the high side, it is necessary to refrigerate the gas sample by an arrangement that will filter the gas, pump it through a cooling unit and then past the sensing element. Here the output signal is recorded as dew point and is used to control a valve in the gas supply line either to the endothermic generator or to the furnace. Such equipment has, in fact, been arranged to measure and control the dew point in three zones of a furnace.

Condensation – An analyzer which uses this principle cools and then condenses water vapor within a narrow slot between two electrodes mounted at the end of a cooling element through which the gas passes. The condensed vapor completes an electrical circuit flowing through the nozzle of the cooling chamber and raises the temperature enough to evaporate the condensed vapor. Thus, moisture is alternately condensed on and evaporated from the electrode, and a copper-constantan thermocouple at the electrodes measures the dew point temperature. In this device also the accuracy of measurement is dependent upon the absolute accuracy of the thermocouple. Figure 3 is a schematic drawing of this system. It contains an electrical interlock with the temperature controller which can compensate the dew point reading, furnace temperature, and equilibrium data which correlates dew point with carbon potential. It is claimed that this arrangement permits direct reading of carbon potential.

Fig. 3 – Schematic Circuit of the Carbon Control System Devised by Ipsen Industries, Inc., and Called the "Carbotronic" System.



Available also are alternate versions of the condensation principle where a photoelectric cell is the sensitive device to determine the temperature of condensed vapor on a polished metal or mirror.

Fog formation is available as an indicator only and hence is limited to making spot checks. As far as is known to the author, this principle has not yet been adapted to continuous recording.

Electrolysis is a method whose rather recent development should soon result in a commercial unit. This analyzer uses an electrolytic cell containing a pair of closely spaced electrodes across which a suitable direct-current potential is maintained. The space between the electrodes is bridged by a film of phosphorus pentoxide which has exceedingly small electrical conductivity. When an atmosphere gas is passed over the electrodes, moisture in it reacts with the pentoxide to form phosphoric acid which is a good electrical conductor. Current then passes between the electrodes, the water is electrolysed to form hydrogen and oxygen (which pass out with the gas stream), and the amperage passing between the electrodes is proportional to the concentration of water vapor in the gas. Such a unit is reported to be sensitive to a few parts per billion and is adaptable to continuous recording and controlling.

Infrared Analyzers

Of course there are other active constituents in prepared furnace atmospheres than water vapor. Principal among them are the carbon oxides CO, CO_2, hydrogen, and CH_4. In addition there is a large percentage of nitrogen, ordinarily regarded as inert. Thermodynamic studies have shown that the relative amounts of these constituents must be controlled within fairly narrow limits. It is obvious that before they can be controlled continuously they must be measured continuously.

Such accurate and continuous measurement of

CO_2, CO and CH_4 can be done with an "infrared analyzer" irrespective of the presence of interfering gases. In the latter respect it is superior to gas analyzers which operate on the thermal conductivity principle. Infrared analyzers utilize two fundamentals, namely, *(a)* each gas compound absorbs a certain portion of the infrared spectrum which no other gas absorbs, and *(b)* the amount of radiation absorbed is proportional to the concentration of the specific gas.

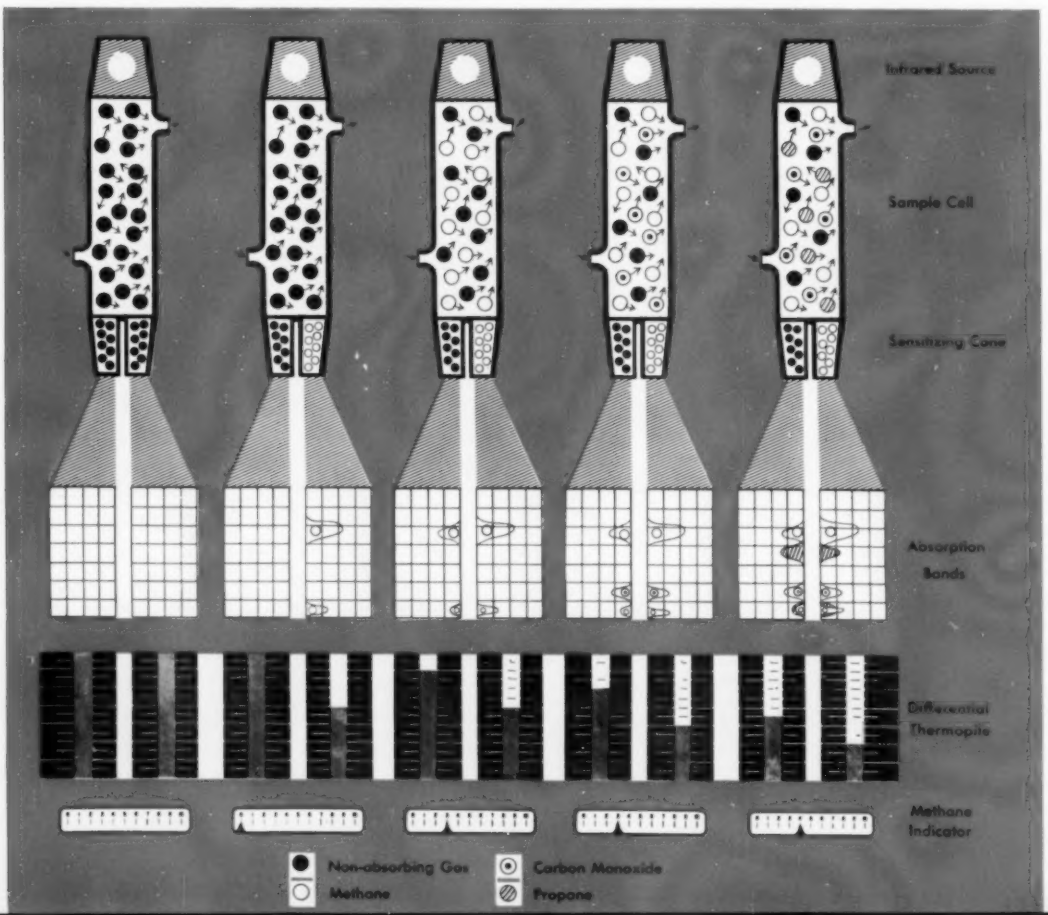
Extremely high accuracy is possible. For example, an analyzer having a full-scale range of 0 to 0.55% CO_2 will have a sensitivity, stability, reproducibility and readability of 0.005% CO_2.

Figure 4 demonstrates how these analyzers sense one gas compound in the presence of others which absorb energy in the same range in the infrared spectrum by using a filter cone. The diagram at the extreme left shows the infrared source at the top, below which is the sample cell filled with nitrogen (a non-absorbing gas); below that are sensitizing cones, and finally a differential thermopile represented by the checkerboard at the bottom. No radiation has been absorbed from the spectrum emitted at the source, and hence both sides of the differential thermopile receive equal radiation and no voltage differential results.

In the second diagram nitrogen still flows through the sample but pure methane has been sealed in the right-hand sensitizing cone. The methane will absorb all the radiation in its two characteristic wave lengths, as shown by the curves on the checkerboard below. Hence the radiation falling on the right side (methane side) of the thermopile decreases, as shown in the white column on the scale at the bottom of the diagram. Since there is actually no methane in the gas sample going through the cell, the differential voltage is adjusted to read zero.

The third diagram from the left represents conditions when the gas being sampled contains 3% methane and 97% nitrogen. This 3% methane absorbs its proportionate amount of the energy reaching the left thermopile (as shown in the checkerboard), while the amount reaching the right thermopile is the same as before – the methane in the sensitizing cone absorbing all that is possible. This difference in energy reaching

Fig. 4 – Sketches Showing the Way an Infrared Analyzer Can Be Used to Determine, Continuously, the Amount of Methane in a Gas Flowing Through the Sample Cell. (Courtesy Leeds & Northrup Co.)



left and right thermopiles is calibrated so the recorder shows 3% methane in the gas sample.

Now suppose that a third gas is present in the mixture – 5% CO, as is shown in the fourth diagram of Fig. 4. It absorbs energy of a characteristic wave length different from that of methane (as shown on the checkerboards) and the energy reaching both thermopiles is less by an equal amount. The difference shown by the white columns continues to indicate 3% methane, and the calibration is unaffected.

However, this is not true if propane is present, as is indicated by the next diagram of Fig. 4. The unequal absorption produced by overlapping absorption results in a reading of 4% methane, which is in error by 1%. This can be avoided by building a filter cell into the sample cell, directly above the sensitizing cone, and filling it with pure propane to absorb all the infrared energy in the characteristic wave lengths for propane. In this way the effect of the interfering gas compound is cancelled, so the recorder again reads the correct value of 3% methane.

In similar fashion interference of other gases can be eliminated.

There is also available another type of analyzer which continuously and directly measures the carbon content of the furnace atmosphere. It is called the "hot wire analyzer" and operates on the principle that at a given elevated temperature the electrical resistance of iron and its alloys changes linearly with the carbon content.

Hot Wire Analyzer

Figure 5 shows such equipment. The primary element, called a "Carbohm"* is inserted into the work chamber and is continuously at the furnace temperature. The furnace atmosphere is continuously drawn past this primary element so it reflects the carbon potential to which the work is being exposed. The primary element is a 3-mil wire, so any change in carbon content at its surface is quickly balanced by diffusion, so the element is of uniform analysis (and electrical resistivity) in a matter of seconds. The tiny element is also remarkably tough at the high operating temperatures.

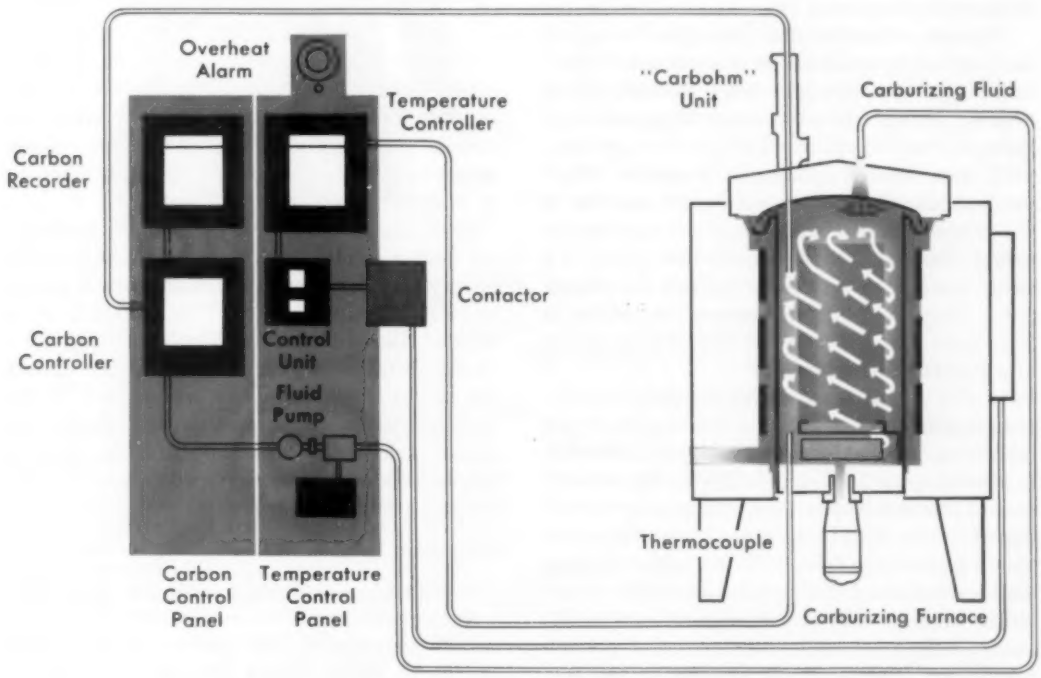


Fig. 5 – Diagram Showing Equipment for the Continuous Measurement (and Control) of Carburizing Potential of Furnace Gases. (Courtesy Leeds & Northrup Co.)

Because the carburizing reaction is reversible, a continuous record is obtained directly in terms of carbon potential. Means are provided whereby this analyzer may be used over a range of

*Reg. U.S. Patent Office.

1450 to 1750° F. Calibration is also automatic. A secondary check can be made occasionally by placing thin shims of 1010 steel in the furnace and allowing them to reach equilibrium with the furnace gas before they are removed and analyzed quantitatively for carbon.

Measurement of Combustibles

Several analyzers are also available which measure and control the total combustibles (such as CO, CH_4 and H_2) in furnace or generator atmospheres. Their basic principles are essentially the same and depend upon the rise in temperature of a platinum filament when exposed to the combustion of metered quantities of the sample gas and air.

Figure 6 shows the flow diagram of a typical analyzer. The gas sample at a regulated pressure passes to a mixing chamber through a fixed orifice. Air at constant pressure is also supplied through a second orifice. The mixture then flows over two heated platinum filaments which catalyze the combustion. A minor amount of the products of combustion pass over a compensating filament which corrects the signal for variations in thermal conductivity of the sample gas. Measuring and compensating filaments form arms of a conventional Wheatstone bridge in a standard recording unit.

As the proportion of combustibles in the sample gas increases, the temperature of the measuring filament increases, and this is recorded in percentage of total combustibles. An auxiliary control unit can be provided to regulate the position of a valve in the gas supply line to the atmosphere generator. While the commonest range used is from zero to 10%, total combustible ranges as low as zero to 1% and as high as zero to 50% are available. Accuracies in the order of ± 0.25% are claimed and sensitivity of 0.05% is possible. The over-all response time is of the order of 15 to 30 sec.

Additional Analyzers

The analyzers just described are the more common ones. Several additional quantities might also be measured and these should be mentioned briefly.

Sometimes the quantity of oxygen should be known; analyzers are available for this. Some operate on the paramagnetic property of oxygen – that is, its ability to be drawn by a magnetic field. Ranges of as low as zero to 1% are possible with an accuracy of ± 0.05% and a sensitivity of 0.1%.

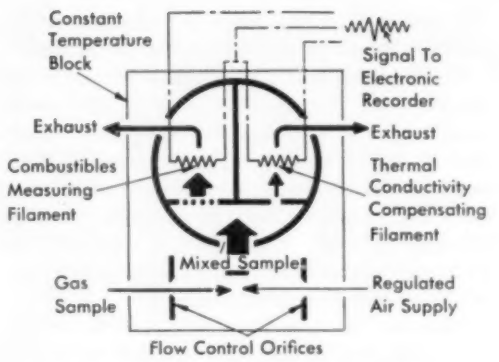


Fig. 6 – Flow Diagram of Method of Measuring Total Combustibles in a Prepared Atmosphere. (Courtesy Bailey Meter Co.)

Another oxygen analyzer operates on the same principle as the combustibles analyzers previously described. Hydrogen is mixed with the sample gas and combusts with the oxygen present in the sample on the platinum filament to raise its temperature and resistance.

Indicating, recording and controlling analyzers are also available which measure the specific gravity of a gas sample. This analyzer is shown in phantom view in Fig. 7 and consists of a rotating motor-driven impeller, revolving in a closed chamber which drives the gas against the blades of an impulse wheel located in the same chamber. A similar device operates on atmospheric air. The combination produces a torque, whose difference is proportional to the specific gravity of the gas.

Automatic Control

Automatic control of furnaces and generators with the analyzers previously described requires careful engineering. The time required to detect changes in the measured value must be kept to a minimum; this requires short pipe lines and rapid flow of the gas sample. Some of the analyzers have a relatively slow rate of response which increases the lag. Contrasted to temperature control, where the heat stored in the furnace walls and metalwork provides a "flywheel" or stabilizing effect, there is no appreciable stabilizing or self-regulating influence in gas atmospheres. Therefore, the control equipment must be of high quality, and be of the proportional position, or input-control type. It should preferably be of the "three function type" – that is, proportional band, rate action, and reset action.

The sample should be taken from a point in the furnace which represents the average atmos-

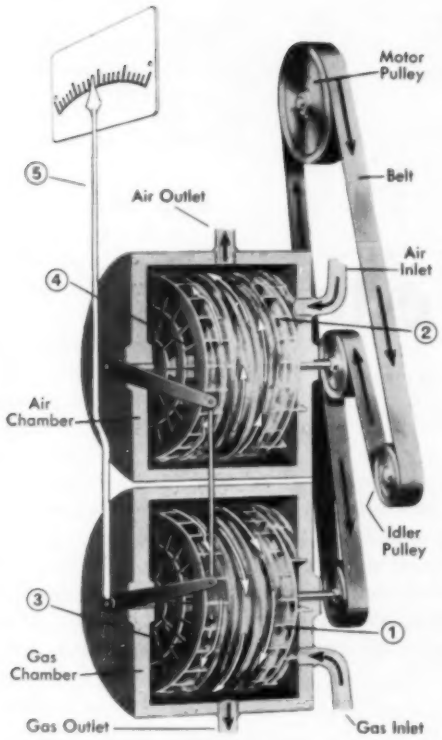


Fig. 7 – Principal of the "Ranarex", Devised by the Permutit Co. for Continuously Measuring the Specific Gravity of a Gas.

1. Impeller (fan) continuously draws in sample of gas to be analyzed and sets it in rotation.

2. Upper impeller draws in air and rotates it in direction opposite to that of gas.

3. Whirling gas strikes impulse wheel and imports torque to its shaft.

4. Whirling air strikes impulse wheel and imports torque in opposite direction to that of gas.

5. The difference between the torque produced by gas and that produced by air moves the indicator.

phere composition. It is essential that the atmosphere be well circulated to avoid any stagnant places.

On furnaces it is normally preferable to maintain the carrier gas flow constant and control the flow of enriching gas.

Generators can be controlled by operating the ratio setter on the carburetor. Another method is to keep the air-gas mixture constant, and use a controlled valve in a bypass line around the carburetor.

It is recommended that the total gas flow to the generator be kept reasonably constant in value; the generated gas which is not being used should be wasted.

Sampling – Too much emphasis cannot be placed on proper sampling procedures. The sample should be taken from the furnace as close to the work as possible. The sampling tube in the furnace must be of a high alloy which will not oxidize and should extend through the furnace wall at least 4 in. There should be a filter just outside the wall, and a shut-off valve. Pipe lines leading to the analyzers should be of copper, aluminum or stainless tubing (never iron pipe). The lines must be tight and must be kept clean.

Means should be provided for easy cleanout, especially for the sample tube into the furnace, since soot will tend to accumulate here.

With batch-type furnaces – especially when measuring dew point – the equipment should be shut off at low temperatures while air is burning out, since the high dew points then existing would produce condensation in the lines. This would cause erroneous readings, frequently lasting for hours.

For automatic control, it is essential that sample lines be kept as short as possible in order to minimize the measuring lags.

Conclusion

The choice of analyzer for a given application is not an easy one to make. If, for example, the operation requires precise knowledge of several components of the atmosphere, one or more of the independent type analyzers should be used, dew point analyzers for H_2O, and infrared analyzers for CO, CO_2, or CH_4. For safety or for purging purposes, where total combustibles must be known, a combustible analyzer would suffice. In a simple two-component gas system – such as dissociated ammonia or a completely combusted gas – a specific gravity indicator would be satisfactory. Where precise knowledge of the carbon potential is required and where there are large departures from equilibrium conditions such as in batch-type carburizing, the hot wire type of analyzer is indicated.

In any event, the more important consideration is that rugged analyzers are now available from several manufacturers. They have passed the test of industrial usage. This means that those who are interested in the research, development and application of furnace atmospheres should utilize these analyzers to their fullest extent in promoting improved and reproducible metallurgical quality of their products.

Control of Atmosphere Converters

*By WALTER H. HOLCROFT**

Atmosphere generators are economically controlled by proportioning the relative volumes of air and fuel gas pumped into them. Exothermic generators may be simply regulated by temperature or by the combustibles in the gas. Endothermic generators are best operated at constant output, wasting any temporary excess of gas, and controlling either H_2O or CO_2 content of the atmosphere. (X7, J2k, 1-2)

THIS CONTRIBUTION to a conference on "Furnace Atmospheres – Their Properties, Applications, Control and Usage", should be read in the light of the papers on types and on applications by Messrs. Vaughan and Peck respectively, already published in the February and March issues of *Metal Progress*, and of the two other contributions by Messrs. Besselman and Cullen in this issue. Mr. Besselman has clearly described the modern control equipment or instrumentation now available, but for an understanding of how to use these controls, we should know something about the factors which cause the variables which should be controlled and minimized.

A major variable, of course, is the amount of air and fuel gas which is pumped into the atmosphere generator. This paper will discuss methods of controlling this ratio. The methods will depend on the desired analysis of the atmosphere to be produced.

Exothermic Converters

As the word "exothermic" implies, sufficient heat is given off by the reaction between the gas and air supplied to the converter to maintain enough temperature in the combustion chamber for proper and continuing operation. The normal range of mixture ratios used with natural gas is from 6 to 1 (that is, 6 parts air to 1 part of gas) to 10 to 1, representing complete combustion.

Composition of the gas issuing from an exothermic converter using natural gas (substantially pure methane, CH_4) will vary approximately as shown in Fig. 1: 5% CO_2, 12% CO, 18% H_2, 53% N_2 and 12% H_2O for a 5 to 1 air-gas ratio, to 9% CO_2, 74% N_2 and 17% H_2O for 10 to 1 or complete combustion. (If the gas were dried to below-zero dew point the analyses would be approximately 6% CO_2, 14% CO, 20% H_2 and 60% N_2 for 5 to 1 air-gas ratio, and 11% CO_2, 89% N_2 for complete combustion.) It is obvious that the variations in atmosphere composition are primarily dependent on the mixture fed to the converter.

The ratio of gas and air used also determines another thing, as shown in Fig. 1, and that is the exact amount of heat given off by the reaction. Analysis of the combustion products in

*Executive Vice-President, Holcroft & Co., Detroit. A paper prepared for the Industrial Heating Equipment Assoc. for presentation at the National Metal Congress, Cleveland, Oct. 9, 1956.

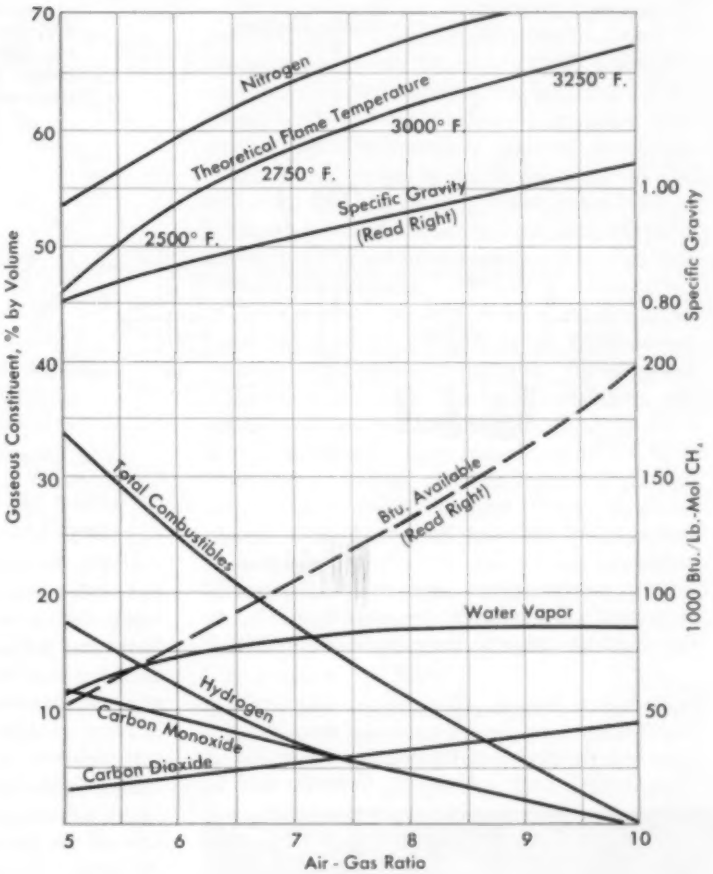


Fig. 1 – Composition and Specific Gravity of Endothermic Generator Gas as They Vary With Air-Gas Ratio Supplied to the Generator

turn governs the specific gravity and percentage of combustibles in the gas produced. For this reason very close control of the mixture ratio is necessary, whether the control be manual or automatic.

Figure 2 shows in black lines the basic piping controlling the mixture. The first necessity is to handle both the gas and air at the same pressure. This is done by using a zero governor on the gas supply line and (for added safety) back-loading it by a small connection with the air supply line. This insures that even if the air filter becomes partially blocked, restricting the air flow, the air and gas will still reach the pump under the same pressure.

The second step is to meter the flow of each. This is done by orifices designed to restrict the flows in the exact proportions desired.

The arrangement shown in black in Fig. 2 is for a constant flow converter. If variable flows are required the piping must be modified, as will be explained later when we discuss endothermic converters. This arrangement also allows only one mixture ratio. To change the outlet analysis of the converter one or both of the orifices must be changed.

The tinted area in Fig. 2 shows a more convenient arrangement. The main gas and air orifices are designed to give a rich mixture ratio such as 6 to 1 for natural gas. Additional air can be introduced through the secondary or bypass orifice to increase the ratio as desired. The bypass is placed on the air line instead of the gas line because it gives more accurate control under the same conditions; obviously a variation in flow of 1 cu.ft. per hr. of air has less effect than 1 cu.ft. per hr. of gas.

The control can either be manual or automatic. If the control is to be automatic, then the question of how to control the valve must be considered.

Any device that can measure continuously and relate its measurements to analysis of the outlet gas can be used to control the bypass valve. Of course, the different methods vary in their degree of accuracy and adaptability, and this must be taken into consideration when choosing a control device.

From the standpoint of instrumentation the simplest method of control is probably by temperature, because some type of pyrometer is normally installed anyway. As is shown in Fig. 1, each mixture ratio has a definite heat release value indicated by the Btu. available. If a constant volume of atmosphere gas is produced, an equilibrium will occur in the converter for each ratio when the heat input exactly balances the heat losses from the chamber. This pyrometric control, of course, requires that the other

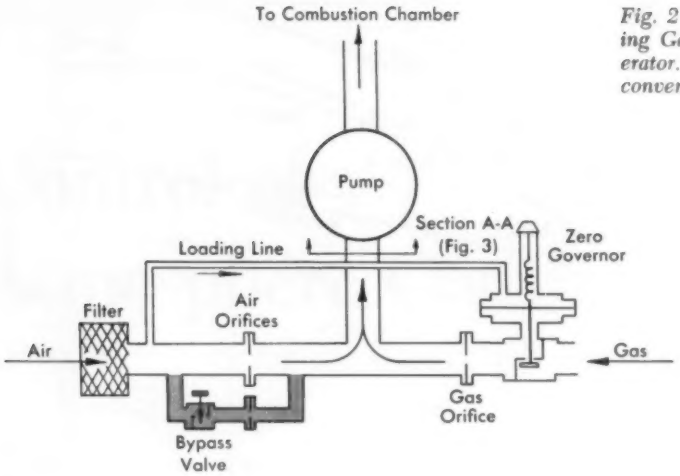
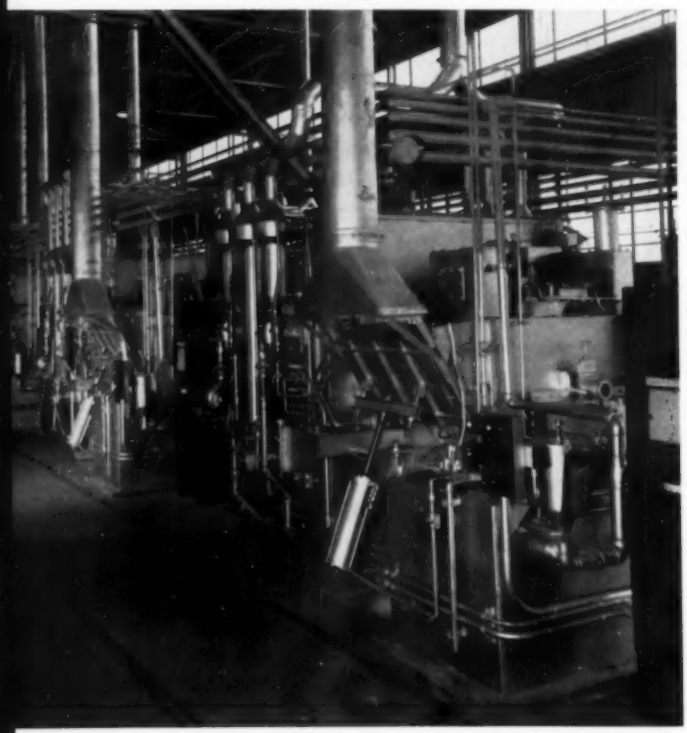


Fig. 2 – Basic Piping Diagram for Supplying Gas and Air to an Endothermic Generator. The bypass valve shown in color is a convenient addition for automatic control

factors which influence the heat balance remain constant.

Other measurements, such as specific gravity or percent combustibles, can also be used. As Fig. 1 shows, either of these can be related back to analysis and, therefore, to mixture ratio.

Fig. 3 – Completely Automatic Unit for Controlled-Atmosphere Processing, Marquenching and Tempering of Various Fixture or Basket-Loaded Parts. (Courtesy Holcroft & Co.)



If we measure the constituents in the outlet gas, water vapor cannot be used because it is mechanically reduced to a constant in the spray tower, but CO_2, CO or H_2 can be used. In the normal use of exothermic gas there is no necessity to measure more than one constituent. Infrared analysis of CO_2 or CO would produce a very accurate means of control.

The final choice as to which measurement should be used to control the mixture ratio must depend on the conditions of the particular installation. The decision must consider the necessary accuracy of control, and the gas components which should be controlled. For example, if total combustibles are of paramount importance in a particular treatment, then it is only logical that the basis of control be percent combustibles. Likewise, if it is necessary to keep the amount of CO_2 between 6.1 and 6.5%, then temperature control might not be accurate enough. A specific gravity instrument could be used, or the CO_2 measured directly by means of an infrared analyzer. Either of the latter methods will give the accuracy necessary.

Occasionally the instrumentation must be capable of controlling a secondary constituent. One such instance comes to mind in the use of exothermic gas for annealing copper. Either small quantities of oxygen or of sulphur will stain the metal. The particular installation used manufactured gas of varying analysis and varying sulphur content. It was found that if we operated in a range of 0.2 to 0.5% CO in the exothermic gas we would have no free oxygen and would have converted all the sulphur com-

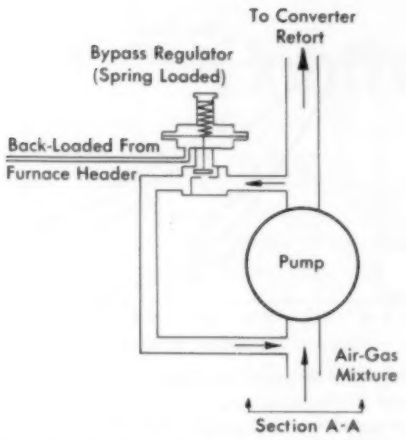


Fig. 4 – Method of Varying Gas-Air Mixture Going Into an Endothermic Converter in Proportion to the Pressure in the Header Carrying the Atmosphere to the Furnace

pounds to SO_2, which could then be absorbed in a spray tower. Accordingly, a device for measuring combustibles was installed to control an automatic valve in the air bypass so as to maintain 0.2 to 0.5% CO in the outlet gas.

Endothermic Converters

The same problems outlined rather briefly above also exist when controlling endothermic converters, producing gas of the so called 20-40-40 analysis (American Gas Assoc. Type 302, 20% CO, 40% H_2, 40% N_2). The only difference is that they are magnified, since the applications of this gas require controls of far greater accuracy. To further complicate the matter, most units are designed to produce automatically a varying amount of gas as the requirements demand. In an endothermic generator the reactions between the incoming air and gas do not generate sufficient heat to keep the process going. Heat must be supplied to the converter – hence "endothermic", or heat absorbing. Furthermore, the chamber or retort is filled with a catalyst which accelerates the rate of the reaction.

The operating temperature of an endothermic converter is somewhat lower than an exothermic unit. The lower limit is approximately 1700° F.; if cooler than this the nickel catalyst rapidly loses its effectiveness. At present the upper limit is limited only by the heat resistant materials available for the retort, but there is little advantage in operating above 1950° F. because capacity is not a direct function of temperature, as it is with the exothermic converter.

The capacity of an endothermic converter is governed by the amount of nickel catalyst *at temperature*. The heat extracted from the catalyst while transforming the gas must be replaced by heat from the heating chamber, and this sets up a temperature gradient across the retort, which depends on the amount of gas converted and the design of the retort. These factors in turn determine the operating temperature of the retort heater necessary to maintain proper outlet analysis.

The gas-to-air mixture ratio plays the most important part in controlling an endothermic converter. Basically the principle of mixing and metering is the same for both exothermic and endothermic converters, even though in the latter the gas-to-air ratio may range around 2½ to 1. Therefore, the actual physical control of the outlet analysis is almost identical with the methods already described. One additional point should be mentioned: Due to the accuracy required it is advisable to use a proportioning type of automatic bypass valve; it gives a closer and more uniform control than possible with an on-off or high-low type of valve.

The basic piping used on the endothermic converters is the same as was shown in Fig. 2 for the exothermic converter with bypass valve on the air line, except that automatic controls are added to govern the converter output. This is normally done by maintaining the pressure in the header leading from the converter at a constant pressure; if the pressure exceeds a preset value, then the flow decreases or vice versa. This is accomplished by using a bypass regulator around the positive displacement mixing pump, as shown in Fig. 4. One side of the regulator diaphragm is loaded to the desired pressure by weights, springs or air. The other side of the diaphragm is back-loaded from the header line carrying the generator gas to the furnaces. When the two pressures are equal the regulator valve assumes a certain position. If the header pressure decreases, thereby calling for more converted gas, the regulator tends to close, thus increasing the flow from the mixing pump. If the header pressure goes up, the regulator opens and decreases the gas flow. The flow variation, of course, has to be within the limits of the converter's capacity.

Varying the converter output in this manner complicates the control by (*a*) increasing the difficulty of maintaining a constant mixture ratio, (*b*) changing the contact time between the gas and the nickel catalyst, and (*c*) changing the

temperature gradient of the catalyst in the retort. Any one of these factors affects the analysis of the outlet gases, and the objective should therefore be to keep the converter flow as constant as possible. One good way to operate single or multiple units, manifolded together under constant outlet conditions, is to set the converter for maximum production requirements at a specific outlet pressure. If less gas is needed the manifold pressure increases, but instead of decreasing the converter flow (as would be done in equipment diagrammed in Fig. 4) the excess gas is spilled out a vent line by an excess pressure regulator.

What measurements are necessary for the proper control of the endothermic converters? This is not a simple question to answer. Of course temperature is measured and controlled on most converters. However, there is not sufficient connection between temperature and outlet analysis to use it for control, as can be done with exothermic converters.

Measurement of specific gravity and combustibles is useful, since there is a direct connection to effluent analysis. However, it is doubtful if they can be measured accurately enough in practice. This leaves actual analysis of one or more of the components present in the gas. The problem, however, must still be handled carefully.

Since endothermic gas is largely used to add or maintain carbon in the surface layers of the parts being heat treated, the primary reason for control is to hold the carbon potential of the generator gas at some constant and predetermined value, and the carbon potential is dependent on the interlocked equilibrium relationships between CO, CO_2, H_2 and H_2O. CO, H_2 and H_2O are related by one reversible equation $C + H_2O \rightleftarrows CO + H_2$. CO_2 is related to the CO in this equation: $2\,CO \rightleftarrows CO_2 + C$.

Therefore, an accurate determination of the carbon potential of an endothermic gas requires either the measurement of CO, H_2 and H_2O, or of CO and CO_2. From either of these sets of measurements the exact carbon potential of the atmosphere can be determined.

Actually, it is not always necessary to determine carbon potential this accurately, for a number of installations operate satisfactorily on the measurement of only one component. This type of control is based on the assumption that the other gaseous components not measured will remain at a relative value and therefore leave the equilibrium unchanged. While this method is not theoretically correct, it does have practical merits. For one thing, it is the easiest and least expensive.

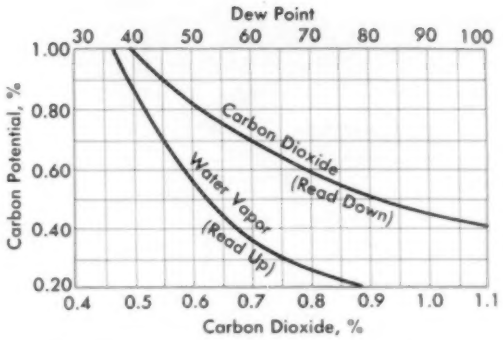


Fig. 5 – Relationship Between Dew Point and Carbon Dioxide in an Endothermic Atmosphere (20% CO, 40% H_2, 40% N_2) at 1500° F. and Its Carbon Potential

Until recently, dew point (moisture content) was used almost exclusively as the single component means of automatic control, primarily because of the price of the dew point equipment and the unavailability of other satisfactory measuring devices. The introduction of infrared analyzers for the easy and accurate measurement of diatomic gases has now changed this situation. The problem in automatic controls is no longer "What can we measure" but "What should we measure?" Assuming that "single component measurement control" will be accurate enough for normal applications, then the decision rests between CO_2 and H_2O when considering a straight endothermic converter gas.

As shown in Fig. 5, although the relationships between carbon potential and CO_2 or H_2O are not identical, either may be used. The relative accuracies necessary for H_2O and CO_2 are represented by the slope of the two curves. To maintain the carbon potential of a Type 302 endothermic atmosphere between 0.90 and 1.00% carbon requires a dew point accuracy of $\pm$ 1.5° F. or a total allowable CO_2 variation of + 0.05%.

The final decision as to which gas or how many gases should be measured and controlled on both exothermic and endothermic converters can only be based on the particular problems pertaining to the individual installation.

If the equipment is carefully purchased and operated on this basis very satisfactory results can be obtained.

Controlling Atmospheres in Furnaces

By ORVILLE E. CULLEN*

Normal operating variables in atmospheres within the furnace can usually be ironed out by instrumentation controlling dew point according to time schedule (in batch-type furnaces) and by individual instruments at two or three zones controlling dew point of carrier gas and additions of carbonaceous gas or liquid (in continuous carburizing furnaces). (X7, J2k, 1-2)

PREVIOUS PAPERS in this conference have described various types of atmosphere control equipment and its use on atmosphere generators. The same types of equipment are becoming more and more important items for direct control of atmospheres *within* the heat treating furnaces. Automatic functioning of this equipment is emphasized and increasing interest is being shown in furnace designs and operating techniques to utilize it to the fullest.

Principles of Atmosphere Control

Atmosphere control, in the sense used in the present discussion, implies the ability to maintain desired atmospheric conditions within a furnace by quickly counteracting any fluctuations which will necessarily occur due to normal operation. In addition, the controls must also overcome, if possible, any unnecessary and unpredictable variations. The variable conditions first mentioned, which are part of normal operation, include intentional changes in temperature, variations in weight, loading characteristics and surface area of work, and mechanical cycling of the furnace. In carbon controlled atmospheres variation in carbon requirements of the steel may be expected.

Unnecessary variations which must also be brought under control quickly can be caused by too limited a range in the control instrument, large changes in atmosphere analysis at the gas generator, extraneous material on work or trays, inadequate sealing devices on the furnace, and faulty operation by personnel. Well-designed automatic control equipment can be adjusted to take care of *normal* variations. Sometimes it takes considerable ingenuity to anticipate the *unnecessary* variables; if severe, the control may be completely inadequate.

The most important point to be stressed in this discussion is the need for a clear understanding of the conditions to be met. Control equipment can function successfully only when it is delegated to perform a previously arranged act or program *within its range of capabilities.* Equipment is *not* a substitute for human intelligence, knowledge or aptitude.

Taking up the second category of variations, a few principles can be set down as imperative if unnecessary variations are to be avoided or held to a minimum:

1. The heat treating furnace must be of suitable design and construction to handle the process in the required manner.

2. The atmosphere generator must be of suitable design to produce the required basic atmosphere. It must be supplied with a suitable hydrocarbon fuel to permit good operation. The generators must receive the necessary competent attention and maintenance. It should be pro-

*Chief Metallurgist, Surface Combustion Corp., Toledo, Ohio. This paper was prepared at the request of the Industrial Heating Equipment Assoc. for presentation at the Joint A.S.M.-I.H.E.A. Conference on Furnace Atmospheres at the 38th National Metal Congress and Exposition held in Cleveland, Oct. 9, 1956.

vided with adequate controls, as previously described by Messrs. Besselman (p. 97) and Holcroft (p. 104).

3. The work should be free from extraneous material which can contaminate the furnace atmosphere, such as scale, heat treat salts, moisture, quenching oils, sulphonated cutting oils, washing compounds, and plain dirt.

The process to be controlled will dictate the general type of instrument to be used. Once it has been chosen, attention must be directed toward its installation at the furnace. There is no need to elaborate on the fact that a perfectly functioning instrument can only control accurately when it is making its adjustments on the furnace atmosphere which is directly in contact with the work. Thus, a correct atmosphere sample is the prime requirement for correct action of the instrument.

Correct atmosphere sampling, as diagrammed in Fig. 1, includes:

1. Proper location of the sampling tube within the furnace. It should be in close proximity to the work or in a position where the furnace atmosphere is substantially the same as that in contact with the work.

2. Proper sizing of the sampling tube. It is important that the sample be unchanged by reactions in or with the sampling tube. Reactions with the tube are usually avoided by using high-temperature alloy. If the gas sample is cooled as rapidly as possible thermal reactions will be avoided; therefore, as small a tube as practicable should be used.

3. Selection of correct filters. While some atmospheres may not require filtration, such equipment is recommended as being necessary in most applications. Filters should be selected bearing in mind the nature of the filter material, minimum pressure drop, and accessibility for maintenance.

4. Selection of sampling pumps. Since almost all furnaces operate at nearly atmospheric pressure, the atmosphere must be pumped from furnace to analyzer and controller by a pump of sufficient size. Naturally the pump, as well as all fittings, must be gas-tight to avoid contamination of the atmosphere gas with air.

5. Tees or crosses should be provided so that lines can be cleaned or dried out as needed. Pipe thread compounds should be avoided if they can contact and contaminate the sample.

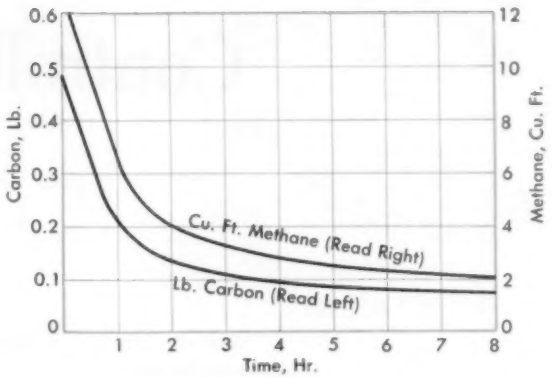
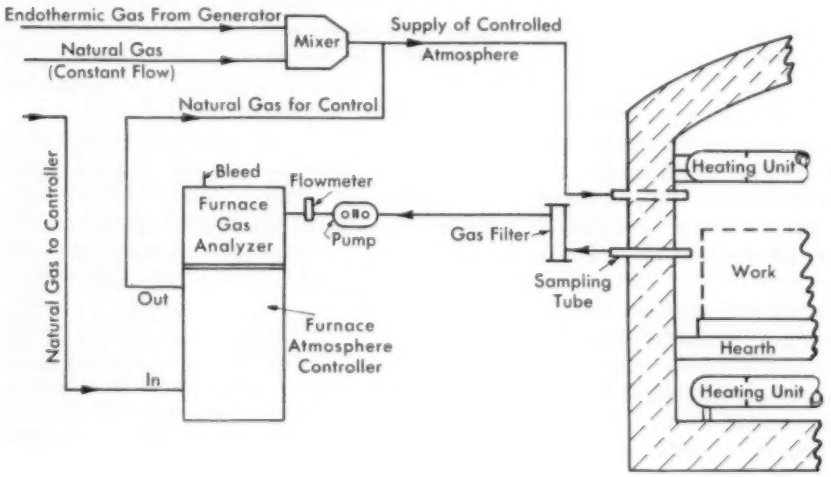


Fig. 2 – Carbon Demand Versus Time of Carburizing at 1700° F. Conditions: 100 sq.ft. of steel surface; constant 1.00% carbon potential in atmosphere; core analysis 0.20% C. Case depth to core analysis in 8 hr. will be 0.072 in.

Fig. 1 – Schematic Layout of Sampling and Control System for Furnace Atmosphere



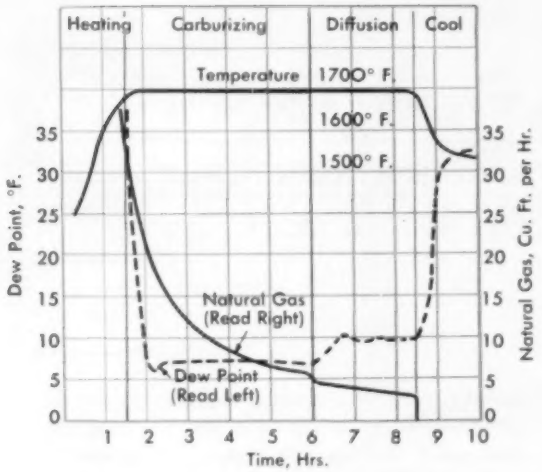


Fig. 3 – Operational Data Chart From Production (Batch Furnace) Operating Under Fully Automatic Atmosphere Control

Relation of Control to Heat Treating Process

Of course, the heat treating process will determine the general type of control equipment to be used. When treating nonferrous metals and alloys, stainless steels and low-carbon steels, control of furnace atmosphere is directly dependent upon proper control of the generator. Indicating or recording instruments are sometimes used to monitor the furnace atmosphere, so undesirable conditions (such as inadequate atmosphere flow, furnace leaks or work contamination) can be detected and remedied by operating personnel. Even though no supplementary gases are added to the furnace for control purposes it should be borne in mind that gas sampling is still an important item if the furnace atmosphere is to be monitored.

The ultimate in furnace atmosphere control is being applied generally to process various steels which require accurate control of surface carbon, hence close control of carbon potential in the atmosphere – such as hardening, carbon restoring, homogeneous carburizing and conventional carburizing. (Atmosphere controlling equipment for carbo-nitriding has been limited to the carbonaceous portion of the atmosphere, and the advantages of such partial control will not be discussed in this paper.)

It is not difficult to understand why processes involving carbon control should be benefited the most. Oxidation-reduction processes involve the use of carbon dioxide and water vapor as oxidizing gases, and carbon monoxide, hydrogen and hydrocarbons as reducing gases, either singly or in various combinations. In such processes they do not control the *degree* of oxidation or reduction of the metal surfaces, but provide either wholly oxidizing or wholly reducing conditions.

Processes involving carbon control, on the other hand, depend upon balanced ratios of carburizing and decarburizing gases to establish some definite carbon potential at the surfaces of the steel, anywhere between about 0.20% and something over 1.00% carbon. The amounts of the decarburizing constituents, CO_2 and H_2O, now become critical values for determining quite accurately the carburizing potential and therefore the actual percentage of carbon at the surfaces of the steel during heat treatment.

The first necessity then is to provide, within the heat treating chamber, an atmosphere with the desired carbon potential. If the process under consideration is strictly a hardening operation, the primary purpose is to prevent any addition or loss of carbon from the steel. The atmosphere is primarily protective and it can often be completely controlled by instruments at the gas generator. In some instances – particularly when carburized or high-carbon work is to be heated for hardening – the furnace atmosphere must be controlled by regulating a variable flow of hydrocarbon enriching gas at the furnace. This may be more advisable than generating an excessively rich gas mixture, which results in excessive maintenance of the generator. Sometimes the furnace atmosphere must be enriched to overcome inherent gaseous reactions due to cycling of the furnace. In any event, atmospheres for hardening processes are relatively simple to control because little or no carbon demand is present – that is, the hot work is not calling for carbon.

For carburizing, carbon restoration and homogeneous carburizing, the problem becomes entirely different. Here, carbon is being continuously abstracted from the furnace atmosphere and its carbon potential must be constantly maintained at the desired level by adding sufficient carbonaceous gaseous or fluid compounds. This steady depletion of carbon from the atmosphere does not take place at a constant rate but rather at a constantly diminishing rate as the depth of penetration increases.

For example, Fig. 2 shows a hypothetical run wherein a furnace load of 0.20% carbon steel with 100 sq.ft. of exposed surface is to be carburized 8 hr. at 1700° F., resulting in a surface carbon of 1.00% and a case depth of 0.072 in. to

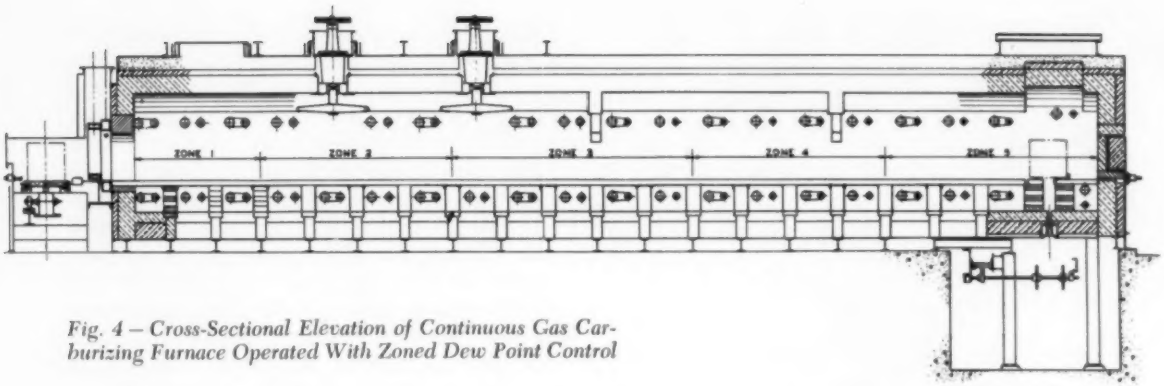


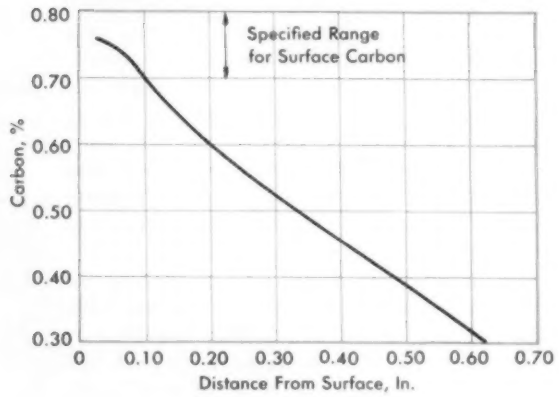
Fig. 4 – Cross-Sectional Elevation of Continuous Gas Carburizing Furnace Operated With Zoned Dew Point Control

core carbon. For simplicity, the heating-up portion of the cycle is not considered or included. The amount of carbon absorbed in a given time is represented by the area under the curve marked "Lb. Carbon". The graph is drawn under the assumption that the carbon potential (and therefore the carbon at the very surface of the steel) is controlled at 1.00% during the entire 8 hr. Approximately 1.15 lb. of carbon will have been absorbed by the steel to produce the carburized case. Approximately 35% of this carbon will have been absorbed during the first hour; the demand drops off rapidly at first, then moves slowly until during the eighth hour only 6% of the total carbon must be supplied. (The upper curve in Fig. 2 represents the amount of methane which will carry the necessary carbon.)

To operate in such a manner, then, is to maintain a constant carbon potential (1.00%), as measured by dew point or carbon dioxide in the furnace atmosphere and as controlled by decreasing the supply of enriching hydrocarbon gas or fluid to the furnace chamber closely in accordance with the curves in Fig. 2. It will be appreciated that anything short of automatic supply of carbon according to demand will result in excessive sooting of work and furnace on the one hand, or failure to realize the full benefits of a good carburized case gradient on the other hand.

This, briefly, is the problem which has been investigated so intently and has created so much interest in various types of instrumentation.

Fig. 5 – Carbon Gradient From Test Bar of A.I.S.I. 8620, Carburized in Continuous Furnace With Zone Dew Point Control



Relation of Control to the Type of Furnace

How is this carbon control handled in production furnaces? Basically, it is necessary to consider two distinct types of carburizing furnaces – the batch furnace, and the continuous furnace.

Batch Furnace – In a batch operation the complete heat treating cycle can be plotted, including the carbon demand curve and other important data, in a manner similar to Fig. 2 but far more completely.

Figure 3 is a chart drawn from data on a production furnace. It shows very clearly the advantages of a carefully planned system of atmosphere control. It will be noted that during the entire active carburizing time the dew point was controlled in the neighborhood of +7° F., which represented a carbon potential of approximately 1.20% C, and consequently insured maximum carburizing rates during this portion of the cycle. Following this came a diffusion period with a dew point of about + 11° F., corresponding to a carbon potential of about 0.95%. The surface carbon of the finished work very closely approximated this value. The case had an excellent gradient with depth of hardenable case (read to 0.40% C) equivalent to work previously carburized in an atmosphere of 1.20% C potential or higher during the entire cycle.

Obviously, the advantage of lower surface

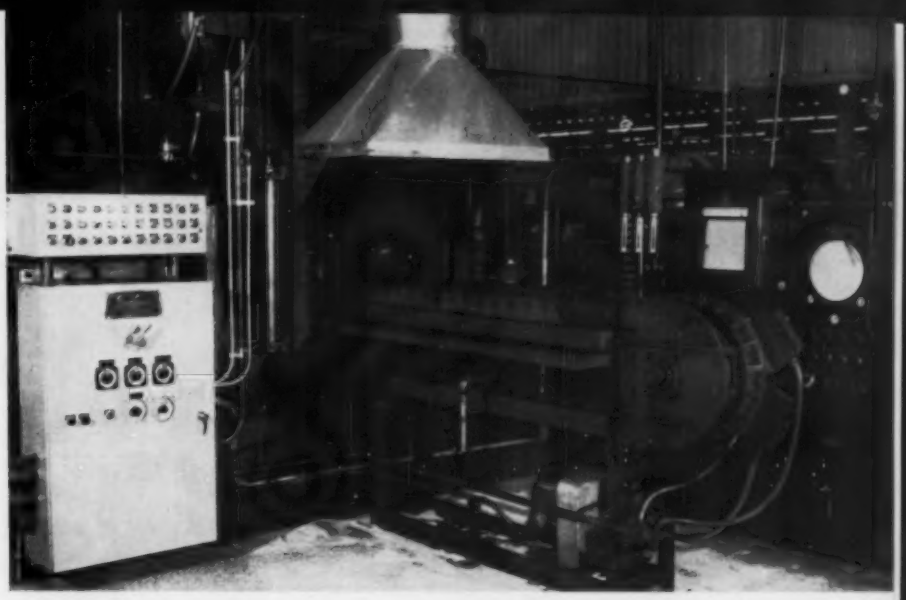


Fig. 6 – Batch-Type Furnace and Equipment for Fully Automatic Atmosphere Control by Dew Point Determination. (Surface Combustion Corp.)

carbon without sacrifice of hardenable case depth was very desirable. Such a treatment is being repeated under automatic control without difficulty on regular production schedules with different types of work, varying furnace loads and different time cycles, as shown in Fig 6. Duplication of such operations by manual control would be out of the question.

The instrumentation automatically controls dew point throughout all the three distinct levels for carburizing, diffusing and equalizing at lower temperature before quenching. The various dew point controls (moisture contents in the furnace atmosphere) are tied into the operation of the furnace – which, incidentally, handles the work on a fully automatic time cycle starting with the green work on the charge table and ending with the quenched work returning to the charge table.

Modifications of this instrumentation have been applied to other types of batch furnaces, as, for example, pit furnaces. Time cycles vary from less than 3 hr. to as long as 96 hr. – the latter for a heavy case of low surface carbon.

It should be evident at this point that batch-type furnaces present the ideal situation for any type of atmosphere controlled heat treatment. They provide the desirable condition that all of the work is at each phase of the processing at the same time. Therefore, program control can be planned on the basis of a definite time cycle with only one atmospheric condition to be considered at any one time.

Continuous Furnaces – An entirely different set of problems may be encountered in continuous carburizing. It is true that conventional hardening and homogeneous carburizing are usually carried out with uniform temperatures, constant gas analysis, and uniform carbon potentials throughout the furnace. Carbon restoration often falls into this same category, but in many other instances it is not so simple. For example, annealing temperatures for forgings, rolled bars, rods and wire coils vary quite widely during the operation and atmosphere requirements change accordingly.

Continuous gas carburizing by the most satisfactory technique probably presents the most difficult example of atmosphere control. It becomes necessary to provide in a single furnace chamber, and at one time, substantially all the conditions present in regular succession in batch furnaces. In spite of these obstacles, automatic control has proven quite successful. Through the use of properly designed and located auxiliaries, such as circulating fans, gas atmosphere inlets and mixers and furnace chamber baffles, one can closely simulate the conditions existing in batch furnaces relative to dew point, gas analysis and carbon potential. The various rather well-defined zones of the continuous furnace function under controlled atmosphere conditions for heating, active carburizing, diffusion and equalizing at intermediate temperatures before quenching.

Figure 4 shows a sectional elevation of a continuous gas carburizing furnace which operates under such conditions. The carbon demanded by the work must be supplied in correct amount at the right time, but also at the right location in the furnace. This is accomplished by establishing two stations for furnace atmosphere control – one in the adjoining portions of Zones 2 and 3, and the second in Zone 5. The control station at Zones 2 and 3 (which are active carburizing zones) supplies the major

portion of the endothermic carrier gas of controlled dew point, and mixes with it the required amount of enriching hydrocarbon gas to maintain a dew point of $+6^{\circ}$ F. $\pm 1^{\circ}$. At the station in Zone 5 a smaller amount of endothermic carrier gas is added to the furnace, plus sufficient air to the carrier gas to provide a dew point of $+ 40^{\circ}$ F. $\pm 2^{\circ}$ in the furnace.

A third station was installed for Zone 4, but has not been needed, since the furnace design and careful venting establish a proper and uniform flow of atmosphere over the work without intermingling the active carburizing gases with gases of lower carbon potential. If this necessary isolation of atmospheres could not be maintained by the present method, the operators could cut in this third station to direct the flow of furnace gases properly and, if necessary, raise or lower the carbon potential in Zone 4.

Figure 5 shows a carbon gradient of a test bar of A.I.S.I. 8620 steel, run through the above furnace when operated to carburize to maintain specified surface carbon level of 0.70 to 0.80%. You couldn't ask for much better.

Metallurgical Topics Discussed by Automotive Engineers

*Reported by J. L. McCLOUD**

Interesting items include a debate on crankshafts (cast versus forged), an exposure of fact and fancy about automation, a session on small gas turbines, and another on engine and transmission wear. (T21, A12h)

THE SOCIETY of Automotive Engineers' Annual Meeting in Detroit in January was particularly noteworthy for metallurgists as the first in which one of our profession presided as president of the Society. W. Paul Eddy, engineering executive of Pratt & Whitney Div. of United Aircraft, took office at this meeting. In this connection, it may be remarked that S. A. E. professional activities are conducted under divisions, one of which is on engineering materials. For several years prior to formal establishment of this division, regular meetings devoted to this subject were held and in one of the very first, W. Paul Eddy – then with General Motors – presented a paper on the N.E. (National Emergency) steels.

Metallurgists and others in materials engineering are proud to have Paul so honored.

Forged Versus Cast Crankshafts

Among the many topics considered at this meeting in Detroit the story of cast versus forged crankshafts was of highest appeal to metallurgists and "played to the biggest house". Harold F. Wood, executive vice-president of Wyman-Gordon Co., was the obvious choice as the proponent of forged steel crankshafts. Drawing upon his many years of successful forging experience he told of the operations involved. In a well-illustrated presentation, he showed the steps of rolling, forging, trimming, twisting, choice of steels now commonly used, the metallurgical quality control, heat treatment, centering, dynamic balance control and final inspection. The mechanical properties of crankshaft steel,

*Consulting Editor, *Metal Progress;* long-time Staff Consultant in Manufacturing Engineering, Ford Motor Co., Detroit.

as well as the effect of modulus of elasticity and endurance limit on design, led to the conclusion that forged steel should be preferred as a crankshaft material.

Then came cast crankshafts. First, Harold N. Bogart, manager of manufacturing research, Ford Motor Co., and H. C. Grant, foundry manager, told the story of this development. It all started with unique dry sand molds and high-carbon graphitic steel. The Ford V-8 and Mercury engines have used them exclusively. The microstructure with areas of graphitic temper carbon gives this metal advantageous characteristics of low wear. Freedom of choice as to the distribution of the metal is another reason for cast crankshafts.

Now the preferred method is to cast nodular iron in shell molds. The "shell" — a thin accurate layer of sand and resin baked on the pattern — is made in matching pairs, which are clipped together, put in a flask, back-filled with shot, and the casting poured. After shaking out of the molds the shafts are so close to finish size that a minimum of machining or grinding is required. The nodular iron, like its predecessor graphitic steel, is highly wear resistant and possesses a high modulus of elasticity, considering it is iron as-cast.

Cast crankshafts require no twisting; furthermore the pins or bearings can be cored out to place metal in the best locations.

K. B. Valentine, assistant metallurgical engineer for Pontiac Motor Div. of General Motors, described some of the metallurgical aspects of the Pontiac V-8 engine's pearlitic malleable iron crankshafts. These too are made by shell molding, and their properties compare favorably to those of the older malleable castings and to the formerly used forgings of 1046 steel.

Of the various methods for making malleable iron, Pontiac uses the recently developed 0.025% bismuth addition combined with a pinch (0.003%) of boron. (This was described by A. L. Boegehold in *Metal Progress* for October 1956, p. 73.) Controlled annealing coupled with air cooling and tempering produces high mechanical properties; elastic moduli of 24,300,000 to 26,700,000 psi. were obtained on test pieces cut from the cast crankshafts.

Endurance as determined by fatigue tests of the pearlitic malleable and forged shafts, is comparable and service was reported as satisfactory in Pontiac engines. Tensile strength is 96,000 psi. at 228 Brinell hardness. Wear tests, necessarily obtained by full-scale engine tests, were said to be no different from forged steel. A particular advantage of these shafts is their improved machinability — where any machining is necessary on these shell molded parts.

So ended an amicable debate, forged versus cast crankshafts. Both varieties have their stout proponents. Both can cite satisfactory experience of millions in successful use in American automobiles.

Automation was interestingly examined by Prof. J. R. Bright of the Graduate School of Business Administration, Harvard University, and by G. H. Amber and P. S. Amber, machine control consultants. Professor Bright listed a series of eight myths, and gave the truth about each.

There are no fully automatic factories at present. There are many highly automatic factories, some even 30 years old, but as yet none actually "fully automatic". (Waltham Watch Co. near the turn of the century had a transfer machine for taking the watch "foundation", a brass disk, from machine tool to machine tool until it was completely finished.) The idea that cost reduction through elimination of labor is the only motive for automation is another myth. Reduction in capital investment through increased production — not necessarily reduction in manpower — is often paramount. Nor can it be said that automation in a plant must cost more than a conventional layout; for a given production it may actually cost less. Automation doesn't inevitably raise maintenance costs. This myth is in part due to mixing it with other costs as a broad item, maintenance.

Nor does automation inevitably mean upgrading of labor skill requirements and imposing a severe retraining problem. There may be scarcity of certain skills, such as hydraulic experts or maintenance electricians trained in electronics, but otherwise there is little evidence that large numbers of distinctly superior skills are required to man a fully automatic plant. Furthermore, labor union officials have been concerned lest automation has nothing to offer but unemployment. Actual and typical examples indicate that this is not true; conversely, safer, pleasanter, easier work is the rule.

Automatic machinery is not responsible exclusively for sensational advances in manufacturing and productivity increases. Rearrangement of machines as well as new methods of moving materials may be the most sensational.

A rather animated discussion pointed up the fact that automation must improve productivity, else it cannot be considered to be justified.

Small Gas Turbines

A rather too-well-filled program concerned the small turbine engine. Much of what was said applied to their best and most economical use. "Small", in this connection, is a loose term and means one thing to one company making the engines of about 1000 equivalent horsepower, and another to a firm making those of a mere 150 hp. (The latter was called "peanut power"!)

Primary use for gas turbines is for airplane power plants. In the minority (a rapidly growing one) are engines for supersonic flight. Interestingly enough, "small" engines may have improved weight-power ratios. Missiles, helicopters, target drones and small aircraft need and use small engines. Power for emergency fire pumps and for boat propulsion is another successful use. One company has been in continual production of rather small-sized turbines for about ten years and some of their engines driving generators have been in use more than five years. Turbine-driven pumps and air compressors have been used in the petroleum industry for a long time. Gas turbines are driving helicopters successfully with versatility and ease of maintenance despite rugged use; ease of production is a principal design consideration.

Stress analysis of small turbines and turbine parts was interestingly described. Both Stresscoat and strain gages are being used either in actual operation or in simulated tests.

Engine size must be related to the particular mission for which the vehicle is intended – that is, altitude, speed or Mach number. For certain missions small unaugmented engines may have superior efficiency to large engines with afterburners. This is a most important matter, for in supersonic flying the question now isn't whether you can do it but how efficiently can you do it. Extra pounds and extra volume can no longer be tolerated. It was reported that supersonic flying is being done in level flight at fairly low levels – a situation where aerodynamic heating is already an important physiological factor to be resisted by the fliers of these jets.

Safety experts attached to the Air Forces pointed out that million-dollar fighter planes are being put into the hands of young inexperienced airmen whose pay is so low that they just don't stay in the Air Force long enough for proper training. Airplanes, too, are becoming increasingly complicated, and maintenance requires so much time that a manpower shortage is evident in this field as well.

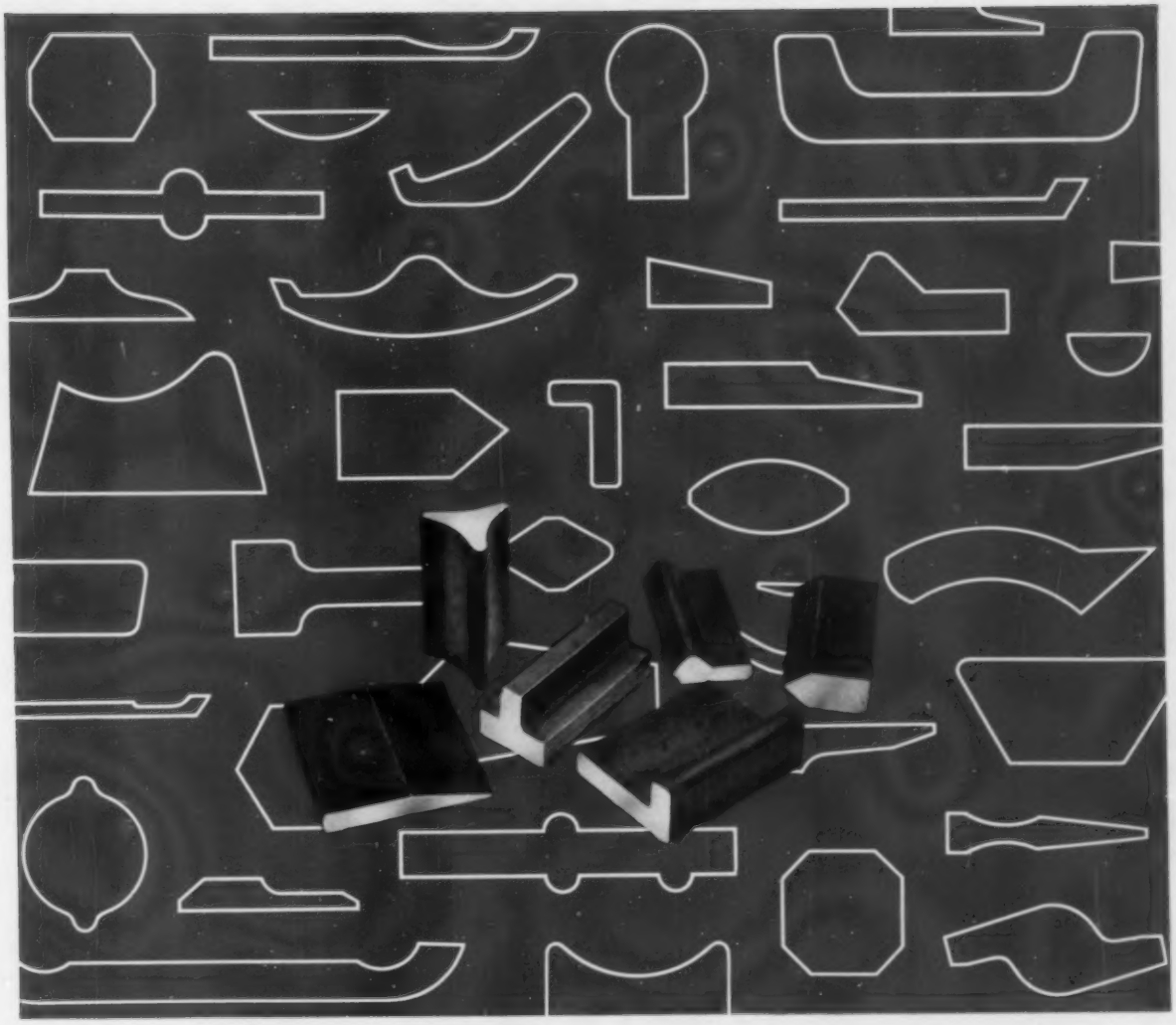
"Why does your car wear out?" was the intriguing general topic which ended an imposing list of papers and sessions at this S. A. E. convention .

The answer to the question is: "Your car wears out mostly from corrosion, although some coincidental deterioration is due to abrasives in the oil." (The dweller in those regions where winter snow and ice are fought with salt will agree that corrosion of the body is the prime enemy. As one put it, "The salt melts the ice and also the car body.") Radioactivity in the oil has been extensively used to monitor this wear; its source is radioactive metal coming from specially irradiated piston rings. H. R. Jackson of Atlantic Refining Co. pointed out that substantial differences in wear occurred when shutdown periods exceeded 3 sec., but there was little difference after one of 20 min. and one of 24 hr. Type of driving – conservative or hot rod – doesn't seem to affect these conclusions, other than to increase wear when short trips predominate.

Vibration was described as particularly important in fatigue failures of antifriction bearings.

A field survey of crankshaft and valve tappet wear was reported by the Coordinating Research Council. Some 16 car makes including eight different combinations of cam and tappet materials were studied, and tests were run on four commercial oils. Differences were noted, oil to oil; metallurgy and design also were responsible for differences in performance. Oil composition had considerable effect on cam and tappet wear when chilled iron or steel tappets were used in the cars. Oils containing zinc dialkyd-dithiophosphate were associated with considerably less wear than those without the chemical; however, too much of the chemical may have undesirable effects on some of the metals.

In one car group, one oil minimized tappet and cam scuffing but increased cam spalling. Oil composition had a marked effect on spalling of chilled cast iron tappets. In two cars the oils virtually eliminated spalling of steel cams, although with the other oils the opposite occurred. Unhardened cast iron cams gave negligible tappet wear against either steel or chilled cast iron. With all other combinations the average tappet wear was approximately the same as the average cam wear. Combinations of hardened cast iron cams with chilled cast iron or steel tappets showed considerably more wear than did hardened cast iron tappets with two of the oils in same cars. (*Continued on p.* 118)



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S.A.E. Meeting . . .

Chilled cast iron tappets were the only ones to show appreciable spalling tendency, but in one make car some designs of these were superior to others. Appreciable cam spalling was observed only with unhardened cast iron cams and was more severe with steel than with chilled cast iron tappets. Oil can affect cam wear more than cam spalling.

Tappett scuffing apparently is affected to a prime degree by metallurgy and design. For example, rotation of tappets offsets both scuffing and spalling. Spalling is worse when wear is least and cam scuffing is not a widespread problem; it generally is associated with increased cam and tappet wear.

Basic Research in Industry

Dr. Lawrence Hafstad, vice-president and director of research staff for General Motors Corp., delivered an after-luncheon talk in which he differentiated between the basic research of scientists and the applied research of engineers. He pointed out that in many instances engineers haven't waited for basic facts and fundamental theories but have solved the particular problems as they were encountered.

An important thing occurred in World War II when engineers cooperated with scientists in "task groups". Fresh approaches by new groups have yielded real "breakthroughs" – witness atomic bombs by physicists and engineers rather than explosives experts. Today, as always, scientists – to continue as scientists – must be free to remain the inquirer.

Dr. Hafstad considers that basic research is not necessarily the responsibility of industry but may be their opportunity, although it is essentially the responsibility of the institutions of higher learning. Industry's responsibility is to apply the findings of the scientist in such a way as to make more and better things for less cost – in short, to be more efficient in manufacturing.

Dr. Hafstad has only recently joined General Motors, leaving an important position with the U. S. Atomic Energy Commission, so his appraisal of motor manufacturing is interesting. He said that the automotive industry tends to become a "mutual admiration society". If a supplier can't make it, it can't be made! In its industrial research much activity relates to product testing and trouble shooting. Such activity must be prompt; if postponed it becomes as expensive as deferred maintenance. An active research laboratory will insure its firm against "new-development isolation", and in this respect one of its functions is to keep the management abreast of such developments and their need to be free-wheeling men, else leadership will become complacent.

Side Issues

The Society of Automotive Engineers has done a good deal to relieve the almost universal stodginess of American technical meetings. A notable effort, a year ago, was a well-written and well-rehearsed playlet where the president of a company brings together his chief engineer,

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sales manager, personnel director, production manager and purchasing agent in a down-to-earth no-holds-barred discussion of a declining profit curve and what should be done about it.

This year the Body Division staged an unusual presentation by J. E. Judge of Ford Motor's Edsel Div. about planning a new automobile. He used slides continuously – not conventional ones, but a projection on a room-wide screen like the Cinemascope. In color (with occasional simulated razzing from a spectator whose likeness was also projected on a smaller screen), it was an arresting presentation of how to cover the desired price ranges, the size the automobile should be, and the features to include. The broad areas of engineering, manufacturing, finance, styling and sales all have to tie together to persuade customers to want this new car. It must not only be sold, but distributed as well as serviced to make these cutomers buy and be loyal to future manufacturing models.

At this session Frederick Jantz of Oldsmobile Div. of General Motors also described a new type of drawing called "graphic illustrations". These are a form of perspective drawings, much more readily read and understood than the conventional three-elevation mechanical drawings, often so woefully inadequate to show curved surfaces and intricate joints in automotive and aircraft construction. They lend themselves particularly well to assembly instruction, and serve sales and service as well as production in a new fashion.

Among those social gatherings, informal and otherwise, which mean so much to engineering groups, a notable feature to some of the veterans in metallurgical work is the annual "Iron and Steel Technical Committee Alumni Meeting". This brought together L. A. Danse, ex General Motors, Harry Knowlton, ex International Harvester, J. L. McCloud, ex Ford Motor, Bill Graves, ex Packard, as well as many still active in industry, like Fred Young, Vic Crosby, Roy Rousch, Bob Sergeson, Ernie Hergenroether and many others.

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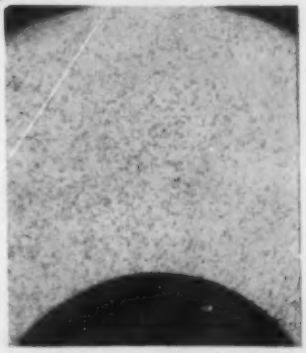

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Personal Mention

Francis G. Tatnall

According to FRANCIS G. TATNALL, there is a great and growing need today for "environmental testing" – that is, the testing of engineering items from complete structures to components under service conditions of maximum severity, and the compilation and evaluation of the results into simple facts for the use of engineers and other scientists. This kind of testing will be one of the main functions of the Tatnall Measuring Systems Co., a new wholly owned subsidiary of the Budd Co., Philadelphia, which Mr. Tatnall will direct as vice-president and general manager.

After graduation from the University of Pennsylvania in 1920, Mr. Tatnall joined the Foamite-Childs Corp., and four years later left to become assistant to the president of Riehle Testing Machine Co., Philadelphia. In 1926, with A. H. Emery and A. C. Tate, he founded the Emery-Tatnall Co. for developing and manufacturing a new line of hydraulic testing machines; two years later the company became associated with Baldwin-Southwark Corp., later Baldwin-Lima-Hamilton Corp. Mr. Tatnall served as manager of testing research from 1943 until his new appointment.

Mr. Tatnall served as local chapter chairman for six technical societies, including the Philadelphia Chapter. He was the Chapter's Metals Man of the Year in 1955.

Tom Bishop

TOM BISHOP, who has been a regular contributor to *Metal Progress* and a European correspondent since the end of the Second World War, has agreed to become a *Metal Progress* consulting editor for Great Britain and Europe.

He was still a captain in the British Army when his first article on "Induction Hardening of Tank Armor Plate" was published in *Metal Progress*, November 1946. He was born in Sheffield, England, in 1919, and rather naturally followed the study of metallurgy, graduating from the University of Sheffield in 1939 with an honors degree.

After a period in the research department of William Jessop & Sons Ltd., Sheffield, he spent the next six years in the British Army, and worked on intelligence reports on the German iron and steel industry, with special reference to armor plate.

He then joined Industrial Newspapers Ltd. in London, and became metallurgical editor of *Iron and Coal Trades Review* and the editor of *Metal Treatment and Drop Forging*. He is well known in British and European metallurgical circles, has a wide knowledge of practical and research aspects of metallurgy, and is a member of many engineering societies on this side of the Atlantic. He is a Fellow of the Institution of Metallurgists.

In January of this year, he relinquished his position with Industrial Newspapers Ltd., and joined the staff of John Miles & Partners (London) Ltd., consultants to metallurgical industries at their head office, 76 Cannon St., London, E.C. 4, England.

Malcolm H. Townsend has been named advisory metallurgist for the marketing department of the industrial heating department, Westinghouse Electric Corp., Pittsburgh. Formerly chief metallurgist with the Burgess-Norton Mfg. Co., Geneva, Ill., Mr. Townsend will have his headquarters at Meadville, Pa.

Robert P. Morgan has assumed new duties as superintendent of the 12-in. and 18-in. C Mills and 21-in. and 24-in. B Mills of Copperweld Steel Co., Warren, Ohio. Employed by Copperweld since 1951, Mr. Morgan was assistant superintendent of rolling mills until recently, and before that worked for Republic Steel Corp., Youngstown, Ohio, and Pittsburgh, and Atlas Steel Ltd., Welland, Ont.

Arthur G. Metcalfe has been appointed supervisor of physical metallurgy at the Armour Research Foundation of Illinois Institute of Technology, Chicago. Dr. Metcalfe will be in charge of research concerned with interrelationships of heat treatment, diffusion of metals, and magnetic and semiconductor materials. He joined the Foundation as research metallurgist in 1953, after serving in that same capacity at the Deloro Smelting and Refining Co., Deloro, Ont., and was named senior metallurgist of the Foundation in 1955.

Charles H. Stoeckle has retired as manager of the Philadelphia sales branch of the Crucible Steel Co. of America, a position he has held since 1932. Mr. Stoeckle's position will be filled by Edward A. Fleming, formerly assistant manager. Joining the sales staff of the Philadelphia branch in 1946, Mr. Fleming served as assistant sales service engineer until he was named assistant manager in 1953.

If you have a **heat-treating** job like this

You need an **Induction Heating Machine** like this

New TOCCOtron Machine 50 kw 500,000 cycles

For many years TOCCO has led the Induction Heating Field—manufacturing both motor-generator and vacuum tube oscillator type machines to meet every induction heating requirement. This new 50 KW TOCCOtron unit is a big brother to the 25 KW unit which has been serving the Metal-Working Industry for many years.

Here's What It Does

With a frequency range of 350,000 to 600,000 c.p.s. the TOCCOtron unit is ideal for surface hardening small diameter parts to shallow depths (as the bearing race illustrated above), through hardening or annealing small sections and soldering or brazing small assemblies where the heating effect must be very strictly localized.

The greater capacity of the new 50 KW TOCCOtron *doubles* production rates formerly achieved by TOCCOtron equipment.

A Really Complete Machine

This radio frequency unit is a truly complete induction heating machine. It contains not only all the direct current supply components and the oscillator components, but also all the control components required for either single or two station operation.

Among the standard features of the 50 KW TOCCOtron are:

1. The industrial heavy gauge steel cabinet which completely encloses all high potential circuits preventing radiation interference and personnel hazards.
2. Meters in all sensitive circuits to enable the user to obtain the maximum output and efficiency.
3. 3-phase quadrature filament excitation of rectifiers for maximum life.
4. Externally adjustable grid bias and drive control for ease in setting up new production runs.
5. Externally mounted circuit breaker and disconnect located so that it is easily accessible.
6. Tapped plate transformer allowing variations of plate voltage.

If your operation requires the hardening, annealing or brazing of very small parts in very big quantities the new 50 KW TOCCOtron can do the job better, faster and at lower cost than any other method available.

THE OHIO CRANKSHAFT COMPANY

Mail Coupon Today—**NEW FREE Bulletin**

The Ohio Crankshaft Co. • Dept: R-4, Cleveland 5, Ohio

Please send catalog G showing TOCCO Induction Heating Equipment from 60 to 600,000 cycles.

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Position_____

Company_____

Address_____

City_____ **Zone**____ **State**_____

Continuous CIRC-AIR Tempering

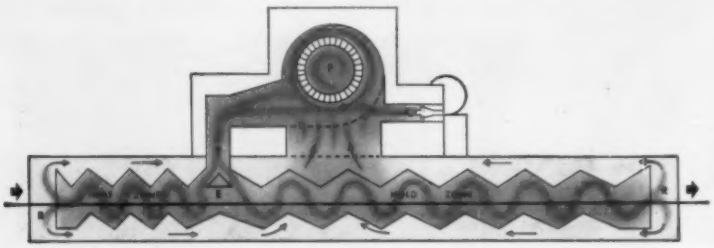
AT ± 5° F.

Industrial's "Circ-Air" tempering furnace is the most efficient heating machine ever designed.

The turbulent recirculation of hot gases through and around the work insures maximum and uniform heat transfer. Proper channeling of the hot gases to the work prevents wasteful dissipation of heat; and puts heat where it is needed — on the work.

A "Circ-Air" processing 2000 lbs. per hour at 1300° F., holding ±5° F., forces 14,500 C. F. M. of hot gases through the work. "Circ-Air" heating is recirculation at its best.

The continuous "Circ-Air" is suitable for heating steel, brass, aluminum and cast iron at temperatures up to 1450° F.



WHY THE CIRC-AIR IS THE BEST TEMPERING FURNACE!

The work is carried on a continuous conveyor. Loading can vary; ¼" bolts are densely loaded up to 3" deep. Less dense loading may be 20" deep. A 3' x 21' "Circ-Air" tempers over 2000 lbs. per hour.

Hot gases from the combustion chamber "C" and recirculated gases returning from the work chamber mix in the fan area "F." Entering the heating area through "T" at control temperature, balanced heat is directed to the charge and discharge ends, and is returned to the mixing chamber. The continuous V construction of the metal liner forces the hot gases up and down through the load at high velocity. The hot gases in the heating zone flow counter to the work. Heat transfer is rapid. Equilibrium is reached at point "E", and ±5° F. is held the length of the holding zone. Heating is without temperature head.

"Circ-Air" furnaces have been built in widths up to 108 inches, in lengths up to 165 feet, for temperatures from 250 to 1450° F., and capacities from 200 to 16,000 lbs. per hour. *Send for Bulletin 13-A*

INDUSTRIAL
HEATING EQUIPMENT CO.

CIRC-AIR 3570 FREMONT PLACE, DETROIT 7, MICHIGAN • WALNUT 3-7000

PIONEERS AND STILL LEADERS IN RECIRCULATION

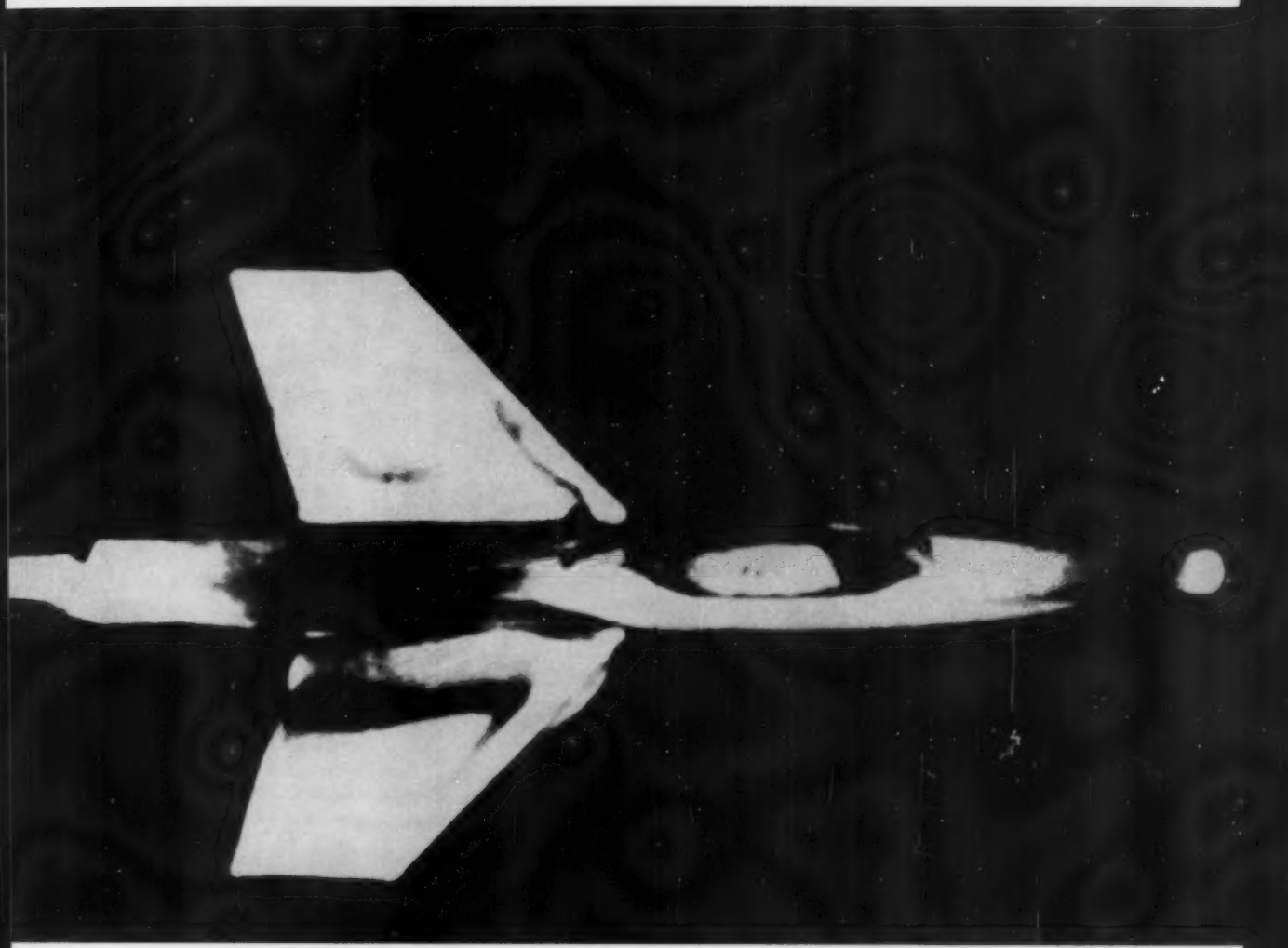
Personals . . .

Norman D. Groves has been chosen to direct the corrosion research activities for Carpenter Steel Co., Reading, Pa. Carpenter is expanding its corrosion research laboratory to broaden its work on corrosion problems in the atomic energy and guided missile fields. Mr. Groves recently joined the company after five years experience as a corrosion engineer at the Hanford Atomic Products Operation, conducted by General Electric Co., Richland, Wash. In his new capacity, he will maintain close liaison with the atomic energy industry and establish cooperative test programs with the U.S. Atomic Energy Commission and private contractors.

Carl Wagner was the recipient of the 1957 Willis Rodney Whitney Award for "outstanding achievement in fundamental work in the corrosion field", presented at the Annual Conference and Exhibition of the National Association of Corrosion Engineers in St. Louis. Dr. Wagner is a professor of metallurgy at Massachusetts Institute of Technology. A native of Germany, he came to this country in 1945 as scientific advisor for the Ordnance Research and Development Division Suboffice (Rocket), Fort Bliss, Tex., and in 1949 became affiliated with M.I.T.

Herbert H. Hager is the new general superintendent, steel production, Firth Stirling, Inc., Pittsburgh. Mr. Hager began his career with the steel division of Firth Stirling in 1937 and last held the position of superintendent of production planning in the division.

Paul Gordon was awarded the Mathewson Gold Medal for 1957 for his contribution to metallurgical science by the American Institute of Mining, Metallurgical, and Petroleum Engineers at the organization's annual meeting in New Orleans. Dr. Gordon is an associate professor at Illinois Institute of Technology, and also was associated with the University of Chicago and Massachusetts Institute of Technology, where he was a metallurgical group leader on the Manhattan Project.



thermal thicket

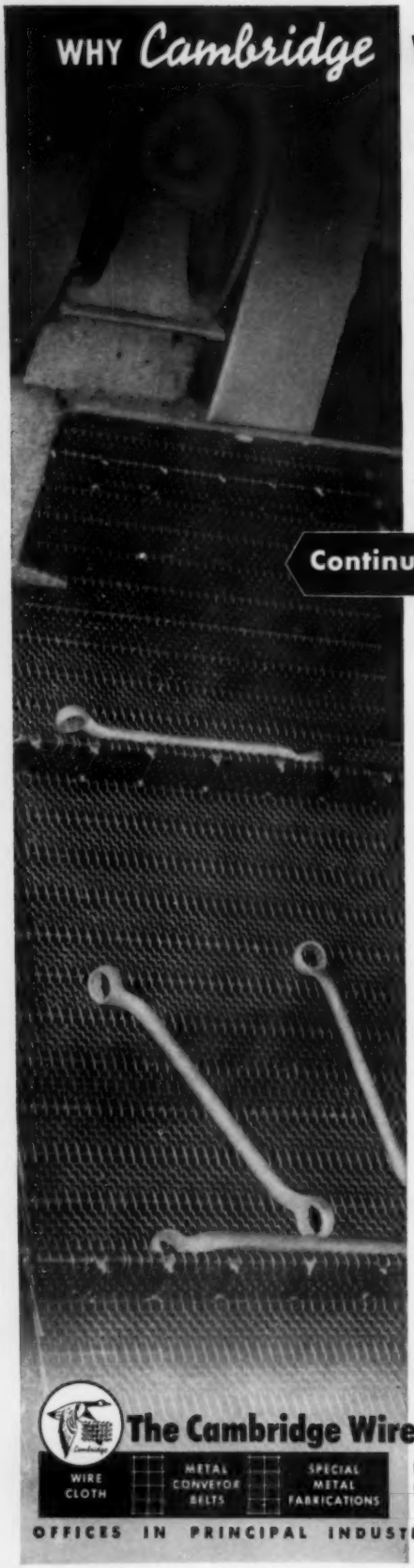
The thermal barrier which now limits the speed of ultra high speed aircraft can be cracked. Needed: Structural components of elevated temperature alloys. Problems: Finding the right alloys; making them easy to forge and machine with regular production-line tools; maintaining uniformity of physical properties in production lots.

Right now, Carpenter is producing elevated temperature alloys which set new standards for consistent ability to meet tough aircraft specifications, high quality, improved forgeability and machinability. Engine builders find them ideal for many critical parts. Forge shops can work them to closer tolerances, get better finishes that require far less than usual machining. Work goes faster. Rejects are fewer.

You can get the full story of these alloys — their application, fabrication and engineering properties — in the new booklet, "Carpenter Alloys for Elevated Temperature Service". Get your personal copy by writing on your Company letterhead. The Carpenter Steel Company, 133 W. Bern Street, Reading, Pa.

Carpenter STEEL

Improved alloys for elevated temperature service


WHY Cambridge
Woven Wire Belts
mean low cost,
continuous heat treating
Baskets and manual handling become things of the past, treatment is more uniform, capacity increases . . . *if* you eliminate batch operation and combine movement on woven wire conveyor belts with annealing, brazing, quenching, oiling, tempering, sintering. Your products move continuously in a belt-to-belt flow all through the heat treat cycle, process costs drop in all departments. FOR EXAMPLE:
Continuous Quenching
ALL-METAL BELT moves wrenches out of quench tank continuously, dumps and returns for more. Woven wire construction from corrosion-resistant alloy provides lasting strength . . . has no seams, lacers or fasteners to break or wear.
SPECIAL CROSS FLIGHTS pick up parts from tank, hold them on the belt during inclined travel.
OPEN MESH permits rapid drainage of quench solution, quick drying of parts—also provides free circulation of atmosphere in furnace cycles for more uniform annealing and brazing.
OPTIONAL CHAIN DRIVE provides positive motion for heavy loads or inclined movement. Friction drive easily handles most loads.
Cambridge Woven Wire Conveyor Belts are made in any size, mesh or weave, from any metal or alloy, and can be used under a wide range of conditions . . . hot or cold, wet or dry. Call your Cambridge Field Engineer to discuss how you can cut costs with continuous processing on woven wire conveyor belts. Look for his 'phone number under "Belting, Mechanical" in the Yellow Pages or write for FREE 130-PAGE REFERENCE MANUAL.
The Cambridge Wire Cloth Co.
WIRE CLOTH
METAL CONVEYOR BELTS
SPECIAL METAL FABRICATIONS
Department B, Cambridge 4, Maryland
Cambridge
CONVEYOR BELTS
OFFICES IN PRINCIPAL INDUSTRIAL CITIES

Personals . . .

Nevzat M. Erkun now holds the post of research metallurgist in the manufacturing research group of Rem-Cru Titanium, Inc., Midland, Pa. Until his recent appointment, Mr. Erkun was materials and research engineer for Pittsburgh Forgings Co., Coraopolis, Pa.

William C. Yager has resigned his position as assistant professor of civil engineering at Pennsylvania Military College to become research engineer in the engineering mechanics sections of Franklin Institute's mechanical engineering laboratory, Philadelphia.

Alan T. Holman has taken a position as plant metallurgist for Morse Chain Co., Ithaca, N. Y. For the past several years, Mr. Holman was associated with the Dow Furnance Co., Detroit, Mich., as a metallurgical engineer.

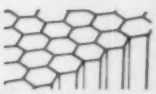
Alec Shapiro, formerly on the instructional staff of the Aeronautics Dept. of the Provincial Institute of Technology and Art, Calgary, Alta., has been named an associate engineer with Boeing Airplane Co., Seattle, Wash.

Edward Hartshorne, general manager of the nuclear fuel division of Olin Mathieson Chemical Corp., New Haven, has been appointed an industry representative on the State Civil Defense Advisory Council by the governor of Connecticut. Mr. Hartshorne has been with Olin since 1934.

William B. Learned now holds the post of manager of the New Haven, Conn., sales branch of the Crucible Steel Co. of America, Pittsburgh. Assistant manager of the branch since 1955, he succeeds **F. J. Dawless**, who is serving as sales consultant. Mr. Learned's former position is being filled by **George C. Benedict**.

Gerald V. Kingsley has been promoted to director of research of Bohn Aluminum and Brass Corp., Detroit. Dr. Kingsley was chief metallurgist for Bohn before his recent appointment.

SECOND HELPINGS FOR SATISFIED CUSTOMERS



To withstand the severe service of aircraft and missile components, a combination of critical requirements is vital in brazing honeycomb materials.

This huge elevator furnace was built by Pacific Scientific to Solar Aircraft Company's specifications to meet these stringent requirements. *A second similar unit is now being built for the San Diego firm!*

Standing 35 feet high, this furnace is designed to come up to high temperatures fast and to operate with extreme uniformity of temperature.

Typical of many specially designed Pacific furnaces, this efficient elevator furnace has a heating chamber with an inside diameter of eight feet, and a depth of ten feet. Typical also is the smooth operation of the furnace door, which lowers and swings out of the way to provide fast cooling to set the braze, and also to allow swift, easy handling and loading.

SOLAR AIRCRAFT'S HONEYCOMB BRAZING GOES SCIENTIFIC.....TWICE!

with this big, new Pacific elevator furnace

Whether your particular heat treating needs are for a giant, special furnace such as this, or for a small, standard-type box furnace . . . Pacific Scientific's advanced designs and construction techniques, backed by long experience, will pay off for you in most efficient, economical performance.

Pacific's heat treating engineers are always available to assist you in selecting the proper type and design equipment for your own particular job. For more specific information . . . call or write *today*.

Pacific INDUSTRIAL HEAT TREATING EQUIPMENT

PACIFIC SCIENTIFIC COMPANY
LOS ANGELES
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SEATTLE
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PACIFIC SCIENTIFIC CO. P. O. Box 22019, Los Angeles, California

Please send me bulletins and specifications on a Pacific Furnace for:
_____ (type of work)

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Company_____
Address_____
City_____ State_____

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poor paint adhesion?

FREE MANUAL
shows how phosphating will solve your problems!

If poor paint adhesion is your problem, chances are you'll find the solution in the Turcoat Phosphating Manual. This booklet describes the complete Turcoat line, tells the full story of phosphating and includes a valuable "Phosphating Reference Chart," which quickly gives the answer to any paint adhesion problem.

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You will be assured of a *permanent paint seal*, simply by using Turcoat as a bond for organic finishing.

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Please send me a copy of the Turcoat Manual without cost or obligation.

Name_____

Title_____ MP

Personals . . .

M. L. Duggins, **L. G. McNelly** and **W. I. Potteiger** have been assigned to the new St. Louis warehouse of Carpenter Steel Co., Reading, Pa. The warehouse will serve users of specialty steels in the southern central states.

Richard M. Stratton has assumed the post of district manager of the Charlotte, N. C., area for Lincoln Electric Co., Cleveland. Prior to his new assignment, he was a welding engineer for the company in Baltimore and, earlier, in Washington, D. C.

Leo M. Elijah recently joined Sylvania Electric Products, Inc., Bayside, N. Y. as a project engineer in the parts division. Until recently, Mr. Elijah was an industrial metallurgist with the Ford Motor Co. of Canada Ltd.

Edwin A. Gee, associated with research and engineering development for E. I. du Pont de Nemours and Co. since 1948, has been named assistant director of sales in the pigments department. He assisted in the initial sales promotion for titanium and had charge of titanium metal research for the pigments department. In 1951, he became, successively, a research supervisor and section manager in the chemical division. He went into the production division as manager of the plant's technical section to guide technical and development work in the department's plants in 1953, and was appointed sales manager of pigment colors last year.

T. V. Philip has joined the research and development laboratory, Crucible Steel Co. of America, Pittsburgh, as a staff metallurgist. After receiving his doctorate in metallurgical engineering from the University of Wisconsin, Mr. Philip worked as a research associate in physical metallurgy at the University of Illinois.

Alvin S. Cohan, formerly assistant director of public relations and advertising, Titanium Metals Corp. of America, has been added to the public relations department of J. M. Mathes, Inc., New York.

Tear this chart out and preserve it

YOUR GUIDE TO COLUMBIA HOT WORK TOOL STEEL GRADES

TYPE AND GRADES	DESCRIPTION	HARDENING RANGE	QUENCH	TEMPERING RANGE	USEFUL HARDNESS
T1 — CLARITE HW	Full tungsten hot work steel with modified carbon and vanadium for highest resistance to softening at elevated temperatures with best wear resistance and medium toughness.	2100° F. to 2250° F.	Oil or Salt Bath	1050° F. to 1250° F.	58/52 Rc
H24 — FORMITE NO. 3	A high tungsten hot work steel with good heat resistance to softening and wear, good toughness.	2000° F. to 2200° F.	Oil or Air	1050° F. to 1250° F.	56/48 Rc
H21 — FORMITE NO. 2	Reduced tungsten hot work steel with good resistance to softening and wear and high toughness.	2000° F. to 2200° F.	Oil or Air	1100° F. to 1250° F.	54/42 Rc
M10 — MOLITE HW10	A high molybdenum 2% vanadium steel with modified carbon for high resistance to softening and good wear resistance with high toughness.	1800° F. to 2100° F.	Oil or Air	1100° F. to 1250° F.	56/48 Rc
H13 — VANADIUM FIREDIE	Air hardening chromium molybdenum 1% vanadium for die casting aluminum, may be water cooled.	1825° F. to 1900° F.	Air	1000° F. to 1200° F.	52/38 Rc
H12 — ALCODIE	Chromium molybdenum tungsten vanadium air hardening hot work steel, resists softening with good resistance to wear and heat checking	1825° F. to 1875° F.	Air	1000° F. to 1200° F.	52/38 Rc
H11 — FIREDIE	Chromium molybdenum with 1/2% vanadium air hardening type with widest range of uses, good resistance to softening and wear with high toughness and may be water cooled.	1800° F. to 1850° F.	Air	1000° F. to 1200° F.	52/38 Rc

COLUMBIA TOOL STEEL COMPANY • CHICAGO HEIGHTS, ILLINOIS

CENTRAL OFFICE AND WORKS, CHICAGO HEIGHTS, ILLINOIS — BRANCH STOCKS IN THE FOLLOWING CITIES:

1957

Chicago 32, 4832 S. Kedzie Ave., Phone LAfayette 3-3632
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Cleveland 14, 1640 St. Clair Ave., Phone MAin 1-1785
Detroit 3, 121 Oakman Blvd., Phone TUlsa 3-3770
Los Angeles 22, 6955 E. Bandini Blvd., Phone RAymond 3-4684
Milwaukee 4, 426 S. Sixth St., Phone BRoadway 6-0255
St. Louis 13, 5118 Easton Ave., Phone FOrest 1-0641

REPRESENTATIVES IN THE FOLLOWING CITIES: Dayton, Erie, Grand Rapids, Hartford, Indianapolis, Louisville, Moline, Newark, Portland and St. Paul

TOOL COLUMBIA STEELS

COLUMBIA TOOL STEELS

DIE STEELS: Superdie — Atmodie — E-Z-Die Smoothcut — Exl-Die — CEC Smoothcut CARBON TOOL STEELS: Columbia Special — Vanadium Extra — Waterdie Extra — Columbia Extra — Columbia Extra Headerdie — Vanadium Standard — Colmbia Standard HIGH SPEED STEELS: Clarite — Vanite — Acmite — Cobite — Maxite — Molite Smoothcut — Molite #3

24 Years of Troublefree Temperature Control!

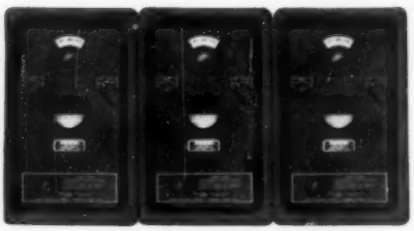
Zone Temperatures in both hardening and tempering sections of this American Gas continuous furnace at Holo-Krome Screw Corporation, Hartford, Conn., are maintained within tolerances of ±10°F by 6 Foxboro Type 4000 Potentiometers (on panel at left). Multi-Record Dynalog* Recorder (center of panel) logs precise temperatures in critical discharge zones.
*Reg. U. S. Pat. Off.

. . . so Holo-Krome again selects Foxboro Type 4000 Potentiometers

Selecting dependable temperature control was no problem when Holo-Krome Screw Corporation recently transferred batch hardening and tempering operations to its new continuous furnace. Foxboro Type 4000 Potentiometers had provided smooth, precise control on batch furnaces . . . requiring only routine preventive maintenance and one major part replacement in 24 years! So Type 4000 got the new assignment — and once again are providing the accuracy and dependability that the company's high quality standards demand.

This is a typical example of thousands of successful Type 4000 applications on heating, annealing, melting, and creep-test furnaces, pickling tanks, and similar installations. They maintain accuracy to ¼ of 1% of scale, sensitivity to a fraction of a degree, give years of troublefree service. Let them help you to get a better quality product and higher productivity. Write for Bulletin 16-10.

The Foxboro Company, 524 Neponset Ave., Foxboro, Mass., U. S. A.



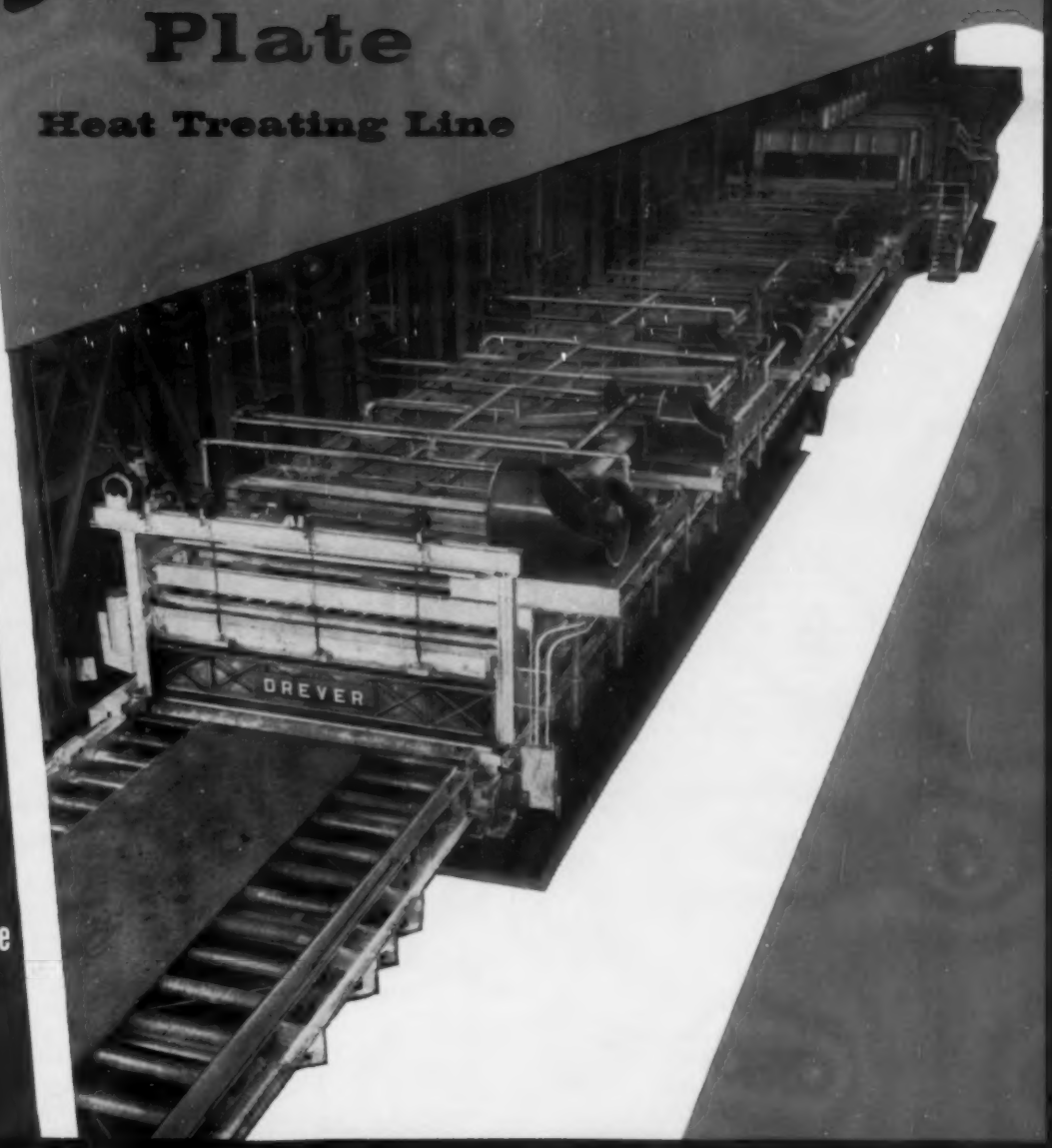
Only one motor is needed to drive up to 5 Type 4000 Potentiometer Controllers . . . real economy without the slightest sacrifice of accuracy or efficiency.

FOXBORO
REG. U.S. PAT OFF.

CONTROLS FOR THE METAL INDUSTRIES

DREVER Plate

Heat Treating Line



Shown is the charging end of a 145'-0" hardening furnace. In the background can be seen a 2500 ton pressure quench, 200'-0" draw furnace and the operator's control pulpit.

This roller-hearth plate heat treating line, known to be the largest of its type, has a capacity to treat plate up to 21-1/2 tons per hour. The equipment is capable of handling plate sizes up to 172" wide x 3" thick x 600" long.

The furnace rolls are 25/12 modified alloy and are designed for a maximum furnace operating temperature of 1850° F.

The maximum fuel capacity for both furnaces is 122,000,000 Btu's per hour.

The entire line is under the control of a single operator. Full utilization of strategically located TV cameras enables the operator to have full control over all operations.

DREVER COMPANY

RED LION ROAD and PHILMONT AVE., BETHAYRES, PA.

MEETING DESIGN NEEDS

FOR HIGH STANDARDS AND LOW UNIT COSTS

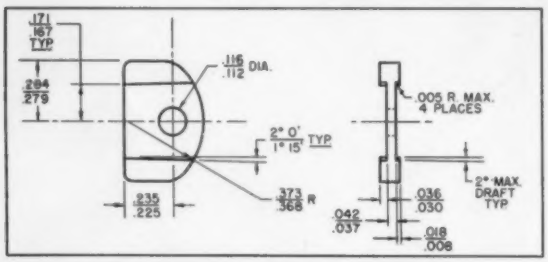
MELETRON USES BRASS POWDER

Design requirements for these automatic electric controls are very rigid because of exposure to extreme temperature, humidity, dust, and vibration in all types of aircraft and industrial equipment. The heart of this Pressure Actuated Switch is the contact element that can be set to a specified change in pressure and then relay the change to an outside electric circuit.

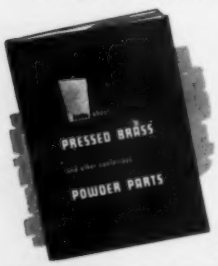
BRASS sinterings were chosen by Meletron, pioneers in the manufacture of Pressure Actuated Switches, for this switch contact because of high electrical conductivity and corrosion resistance. Their fabricator* met the high performance standards of the industry at a low unit cost and, equally important, at a low tooling cost.

When evaluating your design needs, first investigate powder metallurgy. Find out what BRASS AND OTHER NONFERROUS POWDER PARTS can do for your products.

*Pacific Sintered Metals Company, Los Angeles.



How Can BRASS AND NICKEL SILVER POWDER PARTS Meet Your Design Needs?



For detailed information on the design, properties, production and application of brass and other nonferrous powder parts you should have a copy of our manual. It will give you 20 case histories of brass and nickel silver powder structural parts to assist in evaluating this means of production in terms of your particular needs.

SEND FOR YOUR COPY

THE NEW JERSEY ZINC COMPANY
160 Front Street New York 38, N. Y.

Personals . . .

Thomas L. Altshuler, a recent recipient of a master of science degree in physical metallurgy from Columbia University, has joined the staff of the General Electric Advanced Electronics Center, Ithaca, N. Y., as a passive systems engineer.

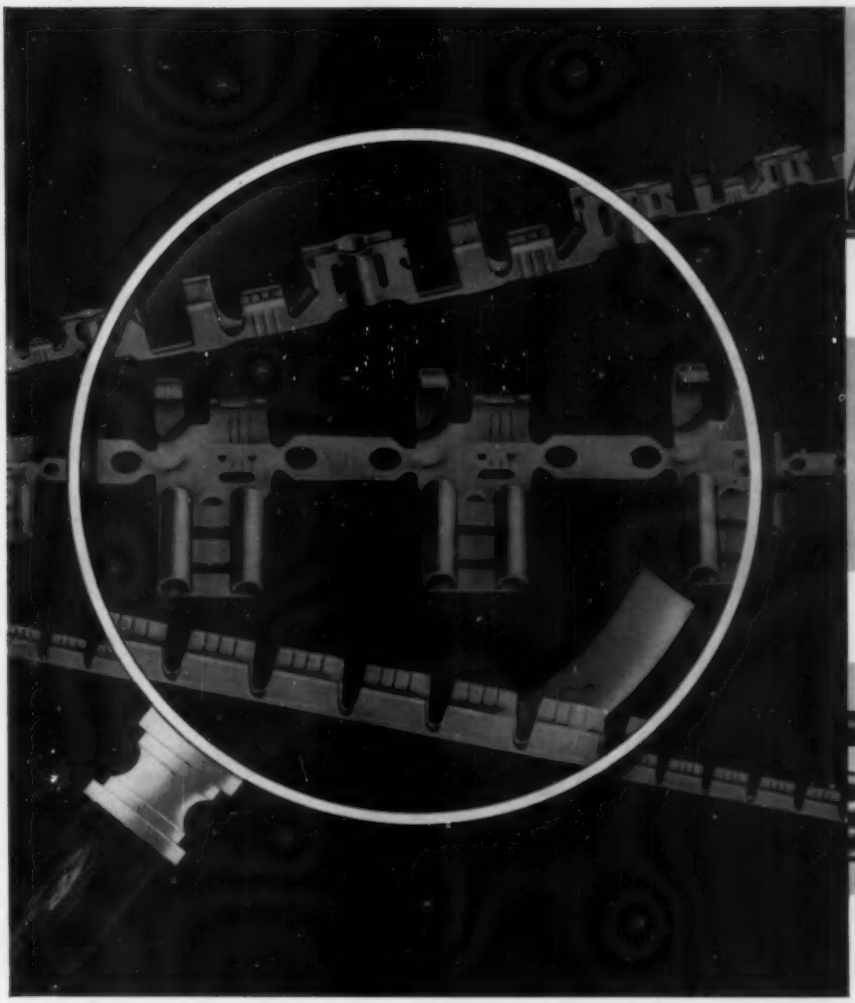
Alfred R. Karow recently accepted the post of chief metallurgist with the National Waterlift Co., Kalamazoo, Mich. His last assignment was as a metallurgist with the Shakeproof Div., Illinois Tool Works, Elgin, Ill.

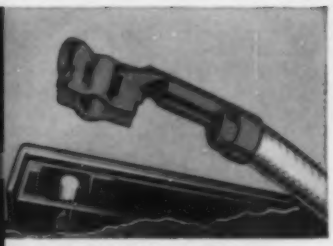
David W. Whittemore, associated with E. F. Houghton & Co. since 1949, has become a member of the sales staff of the Braeburn Alloy Steel Corp., Braeburn, Pa. Mr. Whittemore will represent the company in an area of the New England district.

William J. Hammond, chief application engineer for temperature control equipment, furnaces and ovens, and metallurgical testing machines for the Claud S. Gordon Co., Chicago, has been elected assistant secretary and a member of the board of the company.

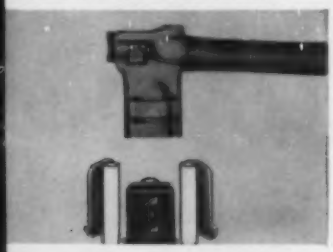
Robert G. Hill was named sales manager of the original equipment division of the Leece-Neville Co., Cleveland. Mr. Hill came to the company in 1941 as a tester, and subsequently served in the engineering department and technical service department. He was appointed sales engineer in 1949, holding this post until his promotion.

John H. Alden is now an assistant chief metallurgist, metallurgical division, Aluminum Co. of America, Pittsburgh, and will coordinate developmental activities for the division. **John W. Hood**, assistant chief metallurgist of the division and head of the company's quality standards department, assumes the additional duty of coordinating control activities of the division. Another new appointment is **Howard J. Rowe**, now chief metallurgist of the fabricating division which incorporates castings division operations.

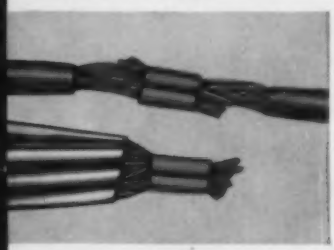




Pin receptacle made of Duraflex—hard temper, in strip form, at left, as fed into the automatic wire terminator. Finished form above.



Flag "Faston," a receptacle for .250" x .032" flat tabs, made of Duraflex—hard temper.



Connector for splicing coil windings to stranded lead wires in hermetically sealed refrigeration motors, made of Duraflex.

For solderless electrical connections that are sealed in

AMP Incorporated turned to DURAFLEX®

Electrical connections inside a sealed refrigeration unit are not easy to service. So, for long, trouble-free operation, it is essential to use superior materials.

AMP Inc., Harrisburg, Penna., is one of the leaders in the development and manufacture of solderless wiring devices. For their connectors to be used in refrigeration service they turned to Duraflex, Anaconda's superfine-grain Phosphor Bronze with superior endurance limit.

The superfine-grain structure of Duraflex offers greatly improved fatigue resistance and formability . . . and a finer, harder, smoother surface. It provides the extra resilience and strength for constant and enduring contact pressure essential in this type of connection. It also offers high resistance to corrosion by the moisture-absorbing additive in refrigerant, plus, of course, good electrical conductivity.

Duraflex is a premium product—yet it costs no more than ordinary phosphor bronze. Find out for yourself how Duraflex can help you cut costs, make a superior product. It is produced in sheet metal up to .062" thick and in wire up to 3/16" diameter. Write today for free samples you can test—specifying gage and temper. Address: The American Brass Company, Waterbury 20, Conn. In Canada: Anaconda American Brass Limited, New Toronto, Ontario.

5674

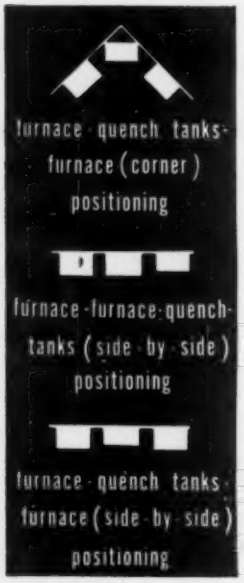
DURAFLEX

The New Superfine-Grain Phosphor Bronze with Greater Endurance Limit

An ANACONDA® Product

Now ...a complete set-up for heat-treating small tools

Waltz small tool furnaces



Contains a pre-heat furnace, a high-heat furnace and quench tanks in a unit designed for convenient positioning in your shop. Furnace sections are equipped with casters.

Temperature range permits treatment of all high speed steels including cobalt type.

Waltz small tool furnaces are "money makers" in many shops throughout the country. Enjoy the lucrative advantages of heat-treating facilities right in your own shop.

A complete line of Waltz standard or special heat-treating furnaces using all types of fuels are built to suit your requirements. Write for comprehensive illustrated bulletins.

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Symmes Street, Cincinnati, Ohio
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Please send without obligation engineering bulletins—Waltz Heat-treating Furnaces.

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COMPANY_____

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Waltz furnace company
SYMMES STREET
CINCINNATI, OHIO

Personals . . .

R. J. Kelly has been added to the sales staff of Electro Metallurgical Co., New York, a division of Union Carbide and Carbon Corp. Mr. Kelly is a sales engineer in Electromet's New York district office in Phillipsburg, N.J. He comes to Electromet after five years of sales experience with John P. Kelly, Inc., Philadelphia, and Volco Brass and Copper Co., Kenilworth, N.J.

Richard G. Frederick has been promoted from assistant manager to manager of the Baltimore sales branch of Crucible Steel Co. of America, Pittsburgh. Joining Crucible in 1935 at the Philadelphia sales branch, Mr. Frederick served there until 1947 when he was assigned to Baltimore as a sales service engineer. He was made assistant manager of the branch in 1953.

Harry E. Hogue has been appointed assistant manager of operations of the Dearborn, Mich., division of Sharon Steel Corp., Sharon, Pa. Mr. Hogue began his employment with the Dearborn division in 1947 and has served in various capacities throughout the division. His most recent position was service representative.

S. S. Rice has joined the J. Bishop & Co. Platinum Works, Malvern, Pa., as chief metallurgist of its precious metals and stainless steel products divisions. Before coming to J. Bishop & Co., Mr. Rice was affiliated with the Ekco Products Co. branch in Oakville, Conn., as chief metallurgist and chief chemist. Prior to that he was assistant to the manufacturing vice-president of the company's main office in Chicago, and before that chief metallurgist and chief chemist at the Massillon, Ohio, plant, where he set up, equipped and administered the metallurgical and chemical departments.

John Vajda has joined the atomic power research laboratory at the Bettis Plant of Westinghouse Electric Corp., Pittsburgh. Mr. Vajda's duties will include engineering and development work on nuclear cores.

Crucible gives you

wide selection,

dependable delivery of

Cold Rolled Specialty Steels

For a *full* selection of cold rolled specialty steels – call Crucible. Deliveries are on-schedule – in the size, grade, finish or length you need.

And Crucible's new mill facilities mean closer control of rolling . . . insure greater physical uniformity . . . fine finish . . . better edges . . . flatter strip.

Whether you use carbon spring steel, alloy strip steel, or many other ferrous analyses that can be cold rolled, you can't beat Crucible. More information is contained in the 32-page booklet, "Cold Rolled Specialty Steels". Write for your free copy now. *Crucible Steel Company of America, The Oliver Building, Mellon Square, Pittsburgh 22, Pa.*

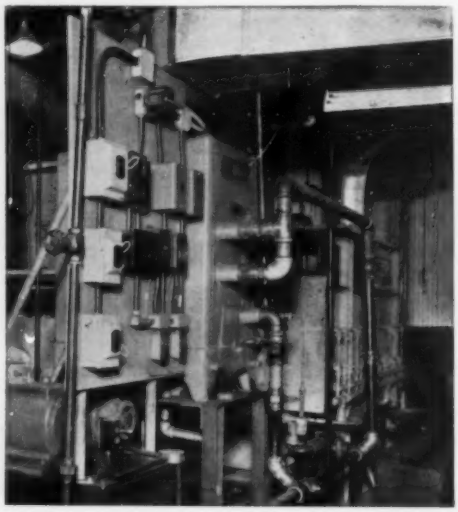
CRUCIBLE first name in special purpose steels

Crucible Steel Company of America

Improve Quenching and You Get Better Heat Treating

Your Department can have a better arrangement with Niagara Equipment that saves much space and increases your production.

This quench bath cooler gives you control of temperature and pays for itself quickly with water savings



● The NIAGARA AERO HEAT EXCHANGER transfers the heat from the quench bath to atmospheric air by evaporative cooling. It never fails to remove the heat at the rate of input, giving you real control of the quench bath temperature. This prevents flashing of oil quenches. In all cases it improves physical properties, saves loss of your product from rejections and gives you faster production, increasing your heat treating capacity. You can put heat back into the quench bath to save the losses of a "warm-up" period.

Savings in piping, pumping and power as well as great savings in cooling water return the cost of the equipment to you in a short time. The Niagara Aero Heat Exchanger saves nearly all of the water consumed by conventional cooling methods.

For the complete story of other benefits and savings, write for Bulletin 120.

NIAGARA BLOWER COMPANY

Over 35 Years Service in Industrial Air Engineering

Dept. MP-4, 405 Lexington Ave. New York 17, N. Y.

Experienced District Engineers in all Principal Cities

Personals . . .

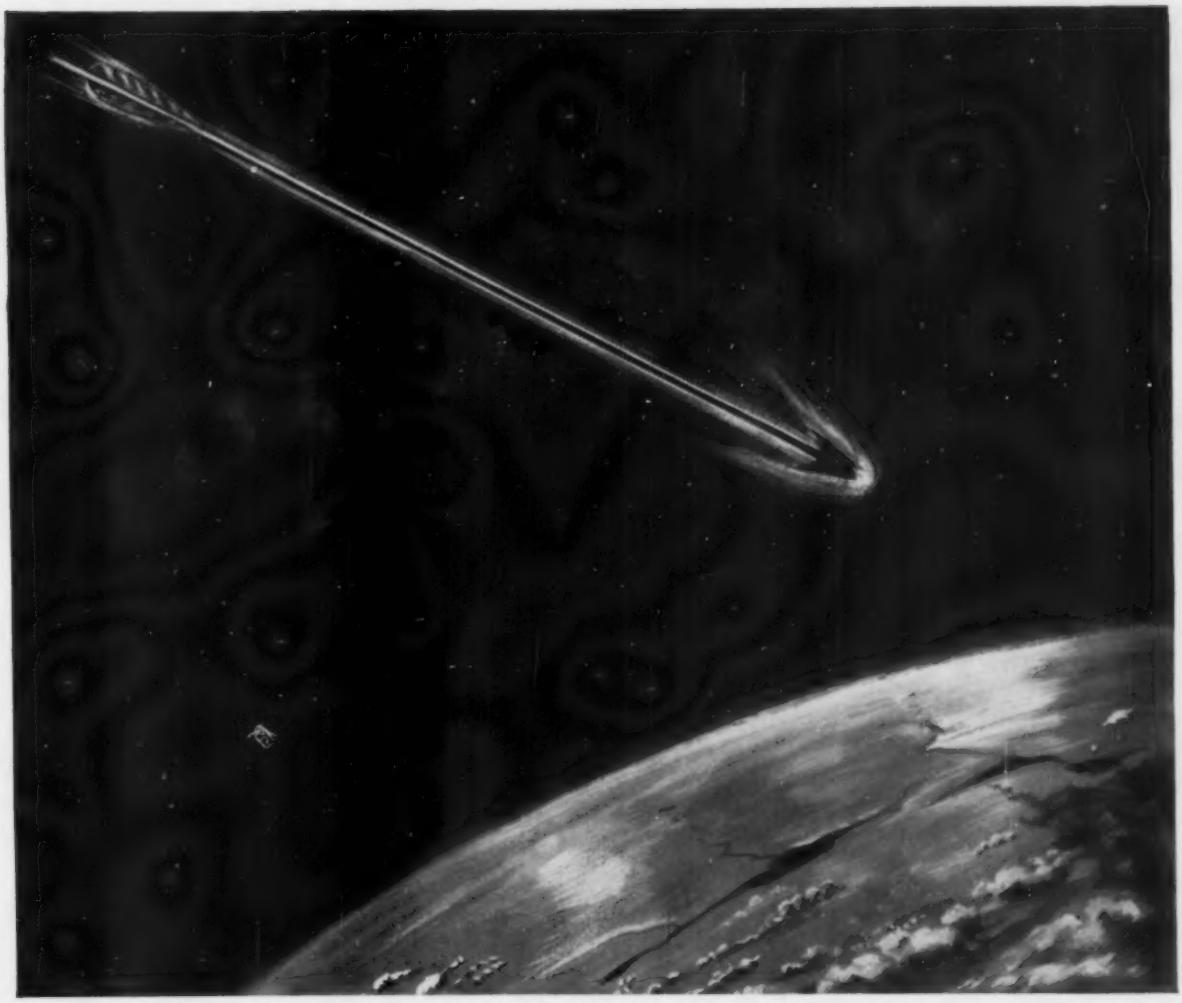
Harry F. Ross has been added to the staff of Ipsenlab of Rockford (Illinois), Inc. Previously a metallurgist at the Central Alloy Div. of Republic Steel Corp., Canton, Ohio, Mr. Ross will hold the position of manager of the company. He has also been associated with the National Acme Co., Cleveland, as plant metallurgist and supervisor of the heat treating department, and Battelle Memorial Institute, Columbus, Ohio, as laboratory metallurgist.

Hiram Brown was recently named technical advisor to the plant manager, Solar Aircraft Co., Des Moines, Iowa, and in this position will serve in an advisory capacity to the plant manager and his executive staff. More recently, Mr. Brown was chief metallurgist for the company.

George C. McCormick has recently been elected president of the Industrial Heating Equipment Co., Detroit, succeeding **Charles E. Buysse**, who has been named chairman of the board of the company. Up to this time, Mr. McCormick had been vice-president and Mr. Buysse president of the company.

Felix Kremp has become assistant product manager, high speed toolsteel sales, for Crucible Steel Co. of America, Pittsburgh. Mr. Kremp joined Crucible's metallurgical department at the Park Works in Pittsburgh after graduation from Cornell University in 1915 and worked for the company four years. He then left the firm but rejoined it in 1934 to work in the general sales department. **E. E. Lull** was transferred from the Syracuse, N. Y., Crucible plant, where he has been staff assistant in the toolsteel sales division, to Pittsburgh as assistant product manager, toolsteel sales.

James R. Blanchard has joined the staff of the production development laboratory, Rocketdyne Div., North American Aviation Co., Canoga Park, Calif., as a senior research engineer. Mr. Blanchard was previously project leader at the research laboratory of Climax Molybdenum Co., Detroit.



When the tip sublimes!

Away up where it's cold, black and lonely at 500,000 ft., the thermal attack on a missile or "airplane" isn't very meaningful. The air molecules at that height are barely nodding neighbors, rather than crammed together in a fluid mass. But, escape and re-entry into the earth's dense envelope of atmosphere generate thermal attacks of frightening ferocity. Nose and leading-edge temperatures may rise to 3000°F.

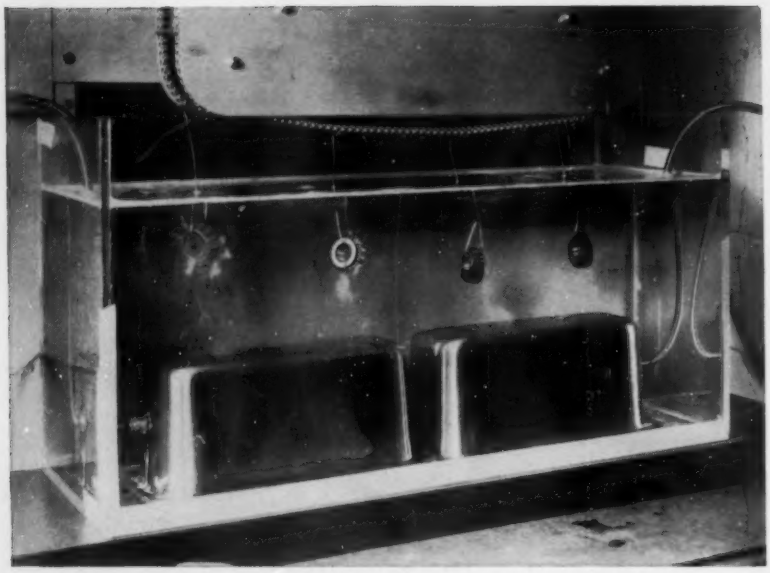
Even titanium won't stand such temperatures for more than a few minutes. For all those areas requiring long-time service life up to 1000°F, however, titanium's light weight, great strength and corrosion resistance offer outstanding design advantages.

Production quantities of very high strength heat-treated sheet, to close gage and flatness tolerances, are being engineered into advanced aircraft and missiles. For non-military applications, all types of mill products are obtainable at constantly lower price levels.

T.M.C.A. is again adding to its production facilities to properly service an ever-expanding market. T.M.C.A. engineering service and technical literature are readily available to all those industries challenged by weight, strength and corrosion problems.

. . . FIRST IN **Titanium**

TITANIUM METALS CORPORATION OF AMERICA, 233 Broadway, New York 7, N.Y.



Largest Immersion Equipment for Ultrasonic Cleaning by GU

Lowest cost conveyorized automatic ultrasonic cleaning is now practical with these new General Ultrasonics D-52 immersion Sonicells. Each unit provides a full 52 square inches of radiating area, operating at 20,000 cycles for maximum effectiveness.

The improved, customer-tested, D-52 has all-welded stainless steel construction and an exclusive internal design that results in great ruggedness, high efficiency and long life. Groups of D-52's provide efficient and economical operation in tanks and vats of unlimited volume in all the usual cleaning solutions.

These Sonicells are powered in large installations by exclusive GU motor generators for maximum dependability. Smaller installations are powered by our Model 700 and Model 400 electronic generators designed for continuous operations. All controls are simple and easy to operate.

The increased power of these new units has proved highly successful for the most difficult and largest cleaning operations to remove dirt, buffing, grinding and lapping compounds and also to replace hand cleaning operations on blind surfaces.

For further information or demonstration call or write.

GU

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THE ULTIMATE IN ULTRASONICS

Personals . . .

Donald D. Goehler, formerly plant metallurgist, Central Brass & Iron Foundry, Portland, Ore., has accepted the position of castings advisor in the metals group, transport division, Boeing Airplane Co., Seattle, Wash.

Donald A. Hanan, for four years Detroit district manager for Peterson Steels, Inc., Union, N.J., has been appointed eastern district manager for the company, with headquarters in Union.

J. H. Whelan, a veteran of more than 33 years' service with the Crucible Steel Co. of America, Pittsburgh, has been given new responsibilities as manager of warehousing. His activities will include locations of new warehouses, expansion of present facilities, material handling and promotional merchandising. Mr. Whelan has served as a warehouse merchandising consultant at the Pittsburgh office since 1955, and prior to that was assistant branch manager of the Chicago sales branch.

Paul P. Hubert, who will report to Mr. Whelan, was named assistant manager in charge of warehouse inventory. He joined the firm in 1952 as a combustion engineer, and since 1956 has worked on inventory control problems.

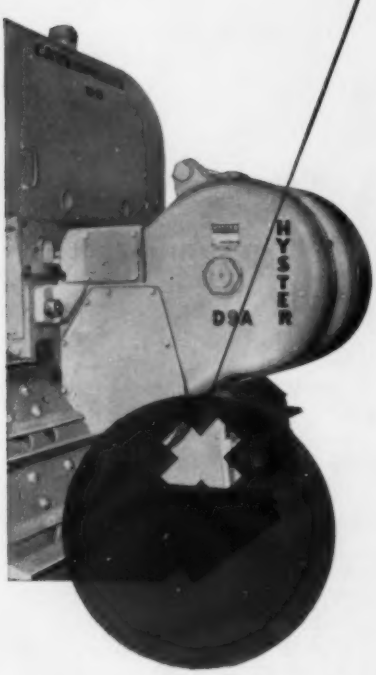
Frank W. Hurd has been chosen director of research for the Union Carbide Nuclear Co., New York, a division of Union Carbide and Carbon Corp. Dr. Hurd has been identified with Union Carbide's activities in the atomic energy field since 1943 when he joined the Manhattan Engineering District Project at Columbia University as a senior research scientist. Later he moved to Oak Ridge where he served as superintendent of the gaseous diffusion plant laboratory. In 1954, he transferred to Niagara Falls to become group manager of the Metals Research Laboratories, later coming to New York to work on a special project for the research administration of Union Carbide. A year later he was appointed superintendent of research and development, industrial applications, for Union Carbide Nuclear Co.

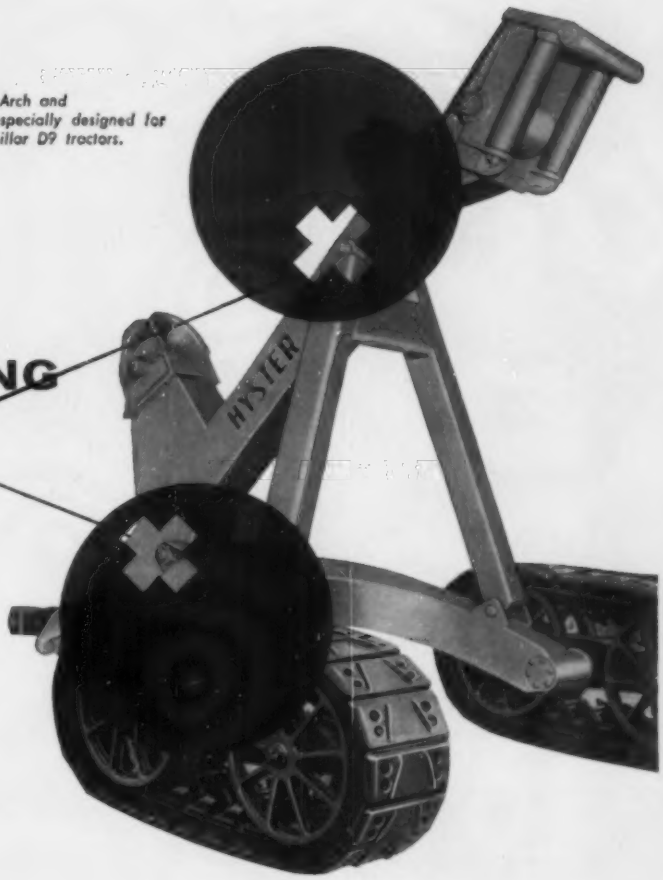
Hyster "98" Logging Arch and D9A Towing Winch especially designed for operation with Caterpillar D9 tractors.

by switching to

OSTUCO TUBING

here and here...





Hyster Company Makes Double-Cut on Costs!

Hyster Company, Portland, Oregon, out to beat machining costs of components in their logging arches and winches and a drawbar bracket, turned the trick by switching from another material to OSTUCO Seamless Steel Tubing.

Drawbar Bracket—Use of OSTUCO Tubing cut material and machining costs from $120,500 to $81,820 annually for a reduction of 32%.

Logging Arch—Used as sleeves in the Hyster "98" Arch, OSTUCO Tubing reduced material and manpower costs 10% annually.

In addition, Hyster engineers report the equipment is stronger and better able to take the strain of heavy hauling and winching jobs over rough logging terrain.

Perhaps you have hidden profit-robbers in your product. Better contact OHIO SEAMLESS for recommendations . . . without obligation on your part, of course.

OSTUCO TUBING

MANUFACTURED IN
SHELBY, OHIO
EXCLUSIVELY BY

OHIO SEAMLESS TUBE DIVISION
OF COPPERWELD STEEL COMPANY

SHELBY, OHIO • Birthplace of the Seamless Steel Tube Industry in America
SEAMLESS AND ELECTRIC-RESISTANCE WELDED
STEEL TUBING • FABRICATING • FORGING

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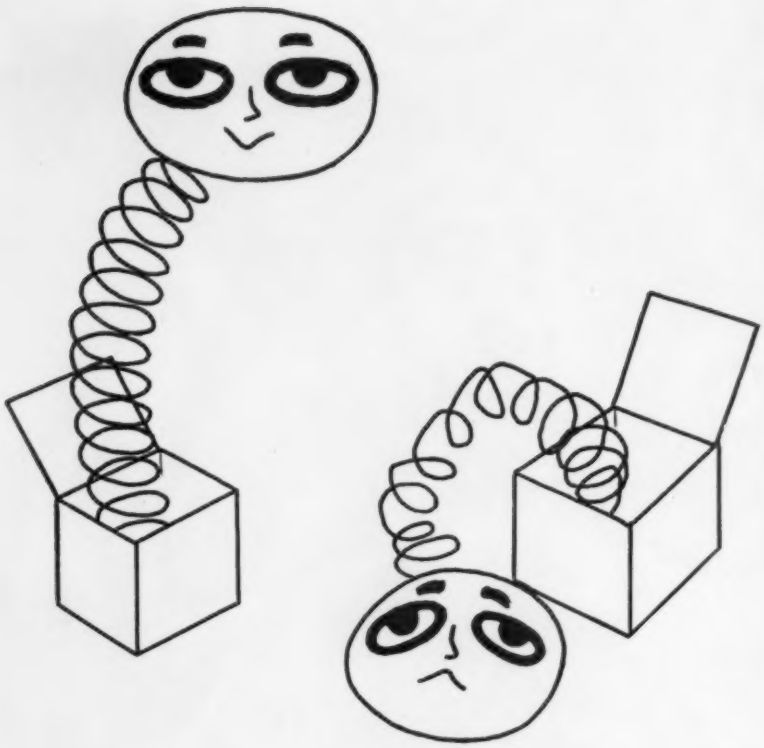
CANADA: Railway & Power Engr. Corp., Ltd.

EXPORT: COPPERWELD STEEL INTERNATIONAL COMPANY, 225 Broadway, New York 7, New York



Some Springs Have It...Some Don't

The difference in spring performance is most often due to the wire or strip used... and there's more to a spring material than just the "bounce". How about other requirements, such as corrosion resistance, high temperature properties, fatigue resistance and low temperature toughness.

When your springs need any of these properties your best bet is one of our alloy spring materials.

Riverside-Alloy Metal Division can supply you with spring wire and strip in stainless steels, nickel alloys, phosphor bronze and beryllium copper.

Learn more about our spring materials. Write to Riverside-Alloy Metal Division, H. K. Porter Company, Inc., Riverside, N. J.

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H. K. PORTER COMPANY, INC.

Personals . . .

Bernard J. McTighe now holds the post of assistant to the vice-president, production, of Hubbard Tool Div., Unit Rail Anchor Co., Inc., Pittsburgh. Mr. McTighe has been with Hubbard Tool Div. since 1922, serving as foreman of the heat treating department, foreman of the finishing department, and since 1945 as superintendent.

Harold M. McCullough has joined the research and development department of Universal-Cyclops Steel Corp., Bridgeville, Pa., as research associate. Dr. McCullough was previously employed by Sylvania Electric Products, Inc., Bayside, N. Y.

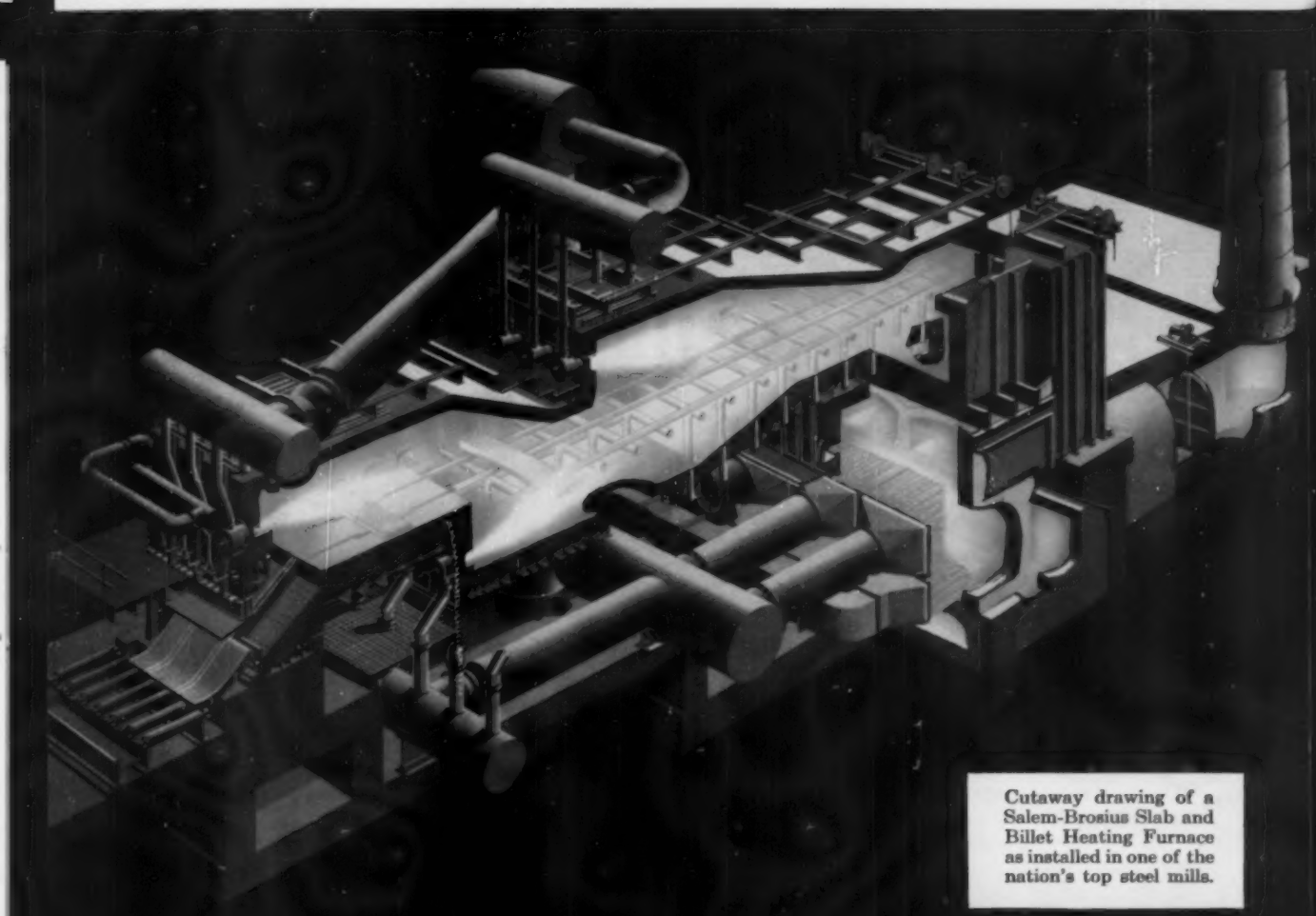
Wynand W. Brandel was recently promoted to the position of chief, factory laboratory, Solar Aircraft Co., Des Moines, Iowa. Mr. Brandel was assistant plant metallurgist, aircraft operations, Allison Div., General Motors Corp., Indianapolis, Ind., until 1955 when he joined Solar Aircraft as resident chief metallurgist.

James R. Butler has left the Pittsburgh Screw & Bolt Corp., Pittsburgh, to accept the position of metallurgical engineer in the product & process development department, Electro Metallurgical Co., Niagara Falls, N. Y., a division of Union Carbide and Carbon Corp.

J. Norton Baker, formerly welding engineer with the metal products division of Goodyear Tire & Rubber Co., Akron, Ohio, has joined the Lincoln Electric Co., Cleveland, as research engineer.

F. J. Bolda is now employed by International Business Machines Corp. in their product development laboratory at Poughkeepsie, N. Y. Before this assignment, Mr. Bolda was a metallurgist for the Southern Railway System, Alexandria, Va.

Robert E. Fish is now a production design engineer, producibility methods, welding section, in the production engineering department, Lockheed Aircraft Corp., Burbank, Calif.



Cutaway drawing of a Salem-Brosius Slab and Billet Heating Furnace as installed in one of the nation's top steel mills.

In this Salem-Brosius furnace better steel products are born

All over the country, steel producers are turning to Salem-Brosius Pusher-Type Slab and Billet Heaters, because they have come to know that these furnaces will produce maximum tonnages of evenly heated, accurately temperatured steel at the lowest fuel consumption rate. The triple-fired furnace shown above features accurately controlled heating and soaking zones, heavy construction, recuperators for fuel economy, dual gas-oil fuel system, low maintenance cost, and many other advantages. These assure positive, automatic control of furnace output and heating quality.

And the efficiency, economy, ease-of-operation, and trouble-free service this furnace affords are typical of all the furnaces Salem-Brosius builds. Whether you require this or any other heating or heat treating furnace, Salem-Brosius offers equipment designed, engineered, and built not merely as a furnace but as a heating machine. You can purchase these furnaces as complete installations—equipped with all controls, piping and wiring—ready to operate. Write to us.

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Digests of Important Articles

Effect of Lead on Properties of Cr-Ni Steels

Digest of "Lead Additions: Effect on the Fatigue Properties of En 24 and En 36 Steels", by W. E. Bardgett; *Iron and Steel*, Vol. 29, August 1956, p. 392-395.

LEAD IS ADDED to steel to improve machinability. English research on the effect of lead addition upon fatigue resistance is considered in this study. Definite comparisons are presented between leaded and nonleaded samples of each of three heats. One heat was a 0.37% C steel containing 1.53% Ni, 1.06% Cr and 0.21% Mo. The others were 3% Ni case hardening steels containing 0.11 to 0.14% C and 0.76 to 0.88% Cr. The leaded samples of each heat contained 0.18 to 0.19% Pb. Test specimens of the 0.37% C steel were oil quenched and tempered to tensile strengths of 125,000, 155,000, and 245,000 psi., and specimens of the 3% Ni steels were quenched and tempered at 750° F., to give a tensile strength of 123,000 psi. for the one with lower carbon and chromium, and 166,000 psi. for the other.

The McQuaid-Ehn grain size of the 0.37% C steel was about 3 to 7, the nonleaded samples being 2 to 6, and the leaded 4 to 8. The lower-carbon steels of 4 to 6 grain size contained a few coarse grains, and hardly any difference was observed in grain size between leaded and nonleaded samples. The microstructures in the heat treated condition were normally martensitic, except in the 3% Ni steel (with lower C and Cr) which contained 30% ferrite in both leaded and nonleaded samples. The other 3% Ni steel (with higher C and Cr) had less than 5% ferrite in nonleaded samples only.

The results of tensile and Izod impact tests at room temperature showed in general from 1 to 20% lower values for the leaded steels in both strength and ductility, though among the 25 sets of data (five properties for each of five heat treatments) five sets of data relating to leaded samples were either equal to or slightly better than the nonleaded ones. The tensile strengths and reductions of area were consistently lower, by 1 to 15%, for the leaded steel, but this inferiority is considered slight and unimportant by the author.

The fatigue tests were made by the Wohler rotating beam method with smooth specimens 0.3 in. diameter, and notched specimens a little larger having a circumferential 55° Whitworth notch 0.02 in. deep. The tests were continued to 10 million cycles. The fatigue limits for smooth specimens in the 125,000-psi. tensile strength class ranged from 58,300 to 71,000 psi.; in the 160,000-psi. tensile strength class from 67,200 to 88,500 psi.; and in the 245,000-psi. class, from 93,000 to 115,000 psi. The fatigue ratios were 0.38 to 0.58 with the higher tensile strengths giving lower values. Notched specimens had fatigue limits between 28,600 and 33,100 psi., except for those heat treated to the highest strength, for which the fatigue limits were 44,900 to 47,600 psi. Their fatigue ratios ranged from 0.18 to 0.26, the lower values again applying to the stronger specimens.

With unnotched specimens the limiting fatigue stress was reduced by lead at all tensile strength levels. In the specimens heat treated to about 125,000 psi. tensile strength, the reduction in fatigue ratio due to lead was 1.8% for the 0.37% C steel and 5.9% for the lower carbon steel. At about 160,000 psi. the fatigue ratios were 5.2 and 12.5% respectively, and at 245,000 psi., 19.1%. With notched specimens, which had much lower fatigue limits, the fatigue ratios were practically identical with and without lead.

Notch sensitivity values did not vary consistently with the tensile strength, but were generally decreased by lead. The decrease, like that produced by lead in the unnotched fatigue limit, was greater with higher tensile strength.

These results are in general agreement with earlier British data. Satisfactory service has been rendered by leaded steel in motor cars, because of the absence of notches in high tensile strength steel.

GEORGE F. COMSTOCK

Coatings for Steel at High Temperature

Digest of "Metallic Coatings for the Protection of Ferrous Metals at Elevated Temperatures", by M. R. Commanday, presented at Los Angeles Chapter ASM Educational Program, Fall 1955, 32 p.

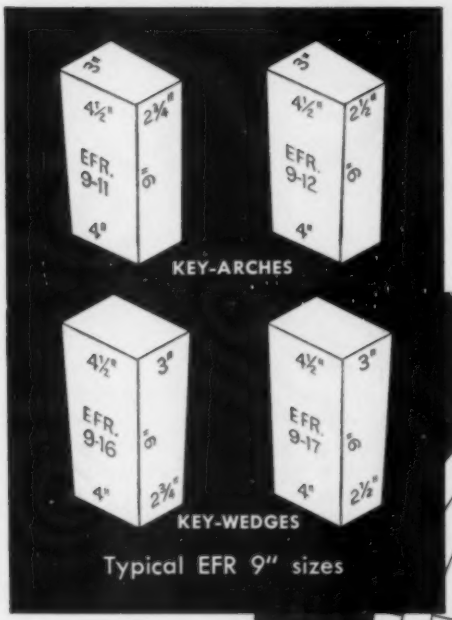
THE INCREASE in operating temperatures of prime movers in the past 50 years has placed greater emphasis on the susceptibility of ferrous materials to corrosion at elevated temperatures. It has been found that by coating steel with materials that form a dense adherent oxide, the service life of the part may be greatly prolonged. There are three major means of applying these coatings: dipping or fusion, spraying, and diffusion or impregnation techniques.

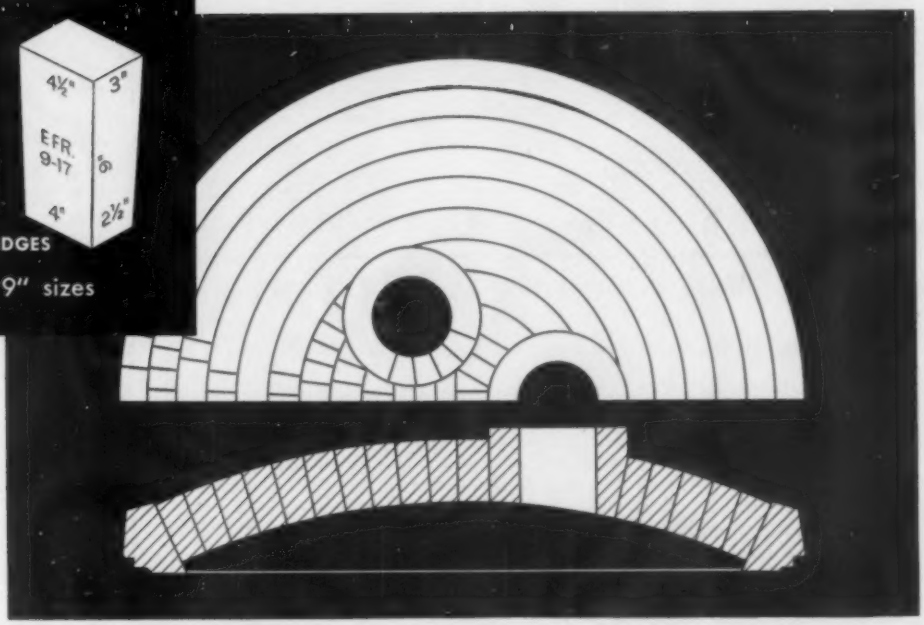
The only dip coating used for elevated-temperature corrosion protection is aluminum. Its unique properties of low melting point, ability to form diffusion coatings with ferrous metals, and adherent refractory oxide make it very useful for protecting steel, even above its melting point. There are several

For electric furnace roofs

Harbison-Walker EFR design

provides important benefits





Harbison-Walker EFR (electric furnace roof) brick are modified 9" key-arches and key-wedges, designed for use in combination with a large proportion of standard 9 x 4½ x 3" sizes in the construction of roofs of any diameter and rise.

The use of these EFR shapes insures a close fit of the brick and roof construction of best workmanship.

The number of different sizes required for building a roof with the aid of the EFR brick is greatly reduced for some designs.

Bricklaying is simplified and much time is saved when EFR brick are used.

EFR brick are power pressed by which method of forming all of the most desirable physical properties are secured.

Roofs built of smaller brick units in preference to large special shapes generally prove to be more serviceable. The smaller sizes are more resistant to thermal shock.

The EFR shapes cost less than large special shapes and since they are used with standard 9" sizes in predominance, the overall cost is considerably reduced.

H-W High Alumina Castable and Korundal Ramming Mix sometimes are used to advantage as a monolith to facilitate easy fitting in the center section.

The EFR brick, together with the standard 9" sizes needed for complete roofs, are furnished in the types and classes of refractories best suited for the various operating conditions. For example, they are made in the following brands: STAR and VEGA silica brick; H-W MULLITE; KORUNDAL; and various Harbison-Walker superduty brands, such as ALAMO and H-W SUPER SAVAGE.

The combination of quality, H-W Technical Service and balanced selection based on availability of all types and classes of refractories from one source, provides maximum economy.

HARBISON-WALKER REFRACTORIES COMPANY

AND SUBSIDIARIES

World's Most Complete Refractories Service

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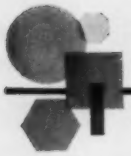

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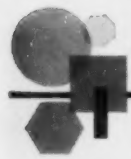

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You'll get quick action on your order for alloy steel bars, billets or forgings . . . no matter what size, shape or heat treatment you require . . . when you call any one of our seven warehouses.

All seven are conveniently located in principal industrial areas.

Each is staffed by expert metallurgists, and is well-stocked to give you speedy service.

Fill your current needs by ordering our own HY-TEN steels, the "standard steels of tomorrow", or standard AISI or SAE grades.

Or write today to our Cambridge office for your *free* Wheelock, Lovejoy Data Sheets. They contain complete technical information on grades, applications, physical properties, tests, heat treating, etc.

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Coatings for Steel . . .

commercial dip coating processes but they all consist essentially of a fluxing treatment to clean the surface followed by dipping in molten aluminum. The Mollerizing process combines the two operations by floating the molten aluminum on top of the molten salt flux so that one immersion fluxes and wets the piece.

Sprayed coatings utilize the useful metallizing gun. The process is very flexible since almost any alloy may be sprayed. There are several problems, however, porosity being the most serious for high-temperature applications. For 1600° F. service, one commercial treatment is to apply 0.006 in. of aluminum and then apply a sealant consisting of aluminum pigment in a bituminous vehicle. The part is then given a short diffusion treatment. For 1800° F. service, a 0.010-in. chromium-nickel alloy coating is used together with the aluminum pigment sealer. This treatment is not suitable for use in a sulphur atmosphere. For temperatures up to 2100° F. and in a sulphurous medium, a 0.015-in. chromium-nickel alloy coating plus 0.004 in. of aluminum plus the aluminum pigment sealant may be used.

Diffusion coatings may be regarded as an alloy enrichment of the metal surface similar to carburizing or nitriding. In this way, large concentrations of expensive alloying elements are provided at the surface where they are needed at a low cost. In fact, higher concentrations of these elements are possible than is practical in a wrought product. The most suitable elements for these processes are aluminum, silicon, and chromium. Commercial processes utilize gaseous compounds in a sealed retort as carriers rather than pack methods. These gaseous compounds include $AlCl_3$, $SiCl_4$, $CrCl_2$ and CrF_2.

Siliconizing offers scaling resistance up to about 1600° F., although this protection is somewhat time dependent above the temperature of rapid diffusion of silicon in steel (about 1500° F.). Siliconizing is probably used more to solve corrosion and wear problems than for high-temperature protection.

Aluminizing or calorizing generally results in a 0.001 to 0.006-in.

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Magnesium was selected because it has the necessary lightness, strength, rigidity, durability and other desirable properties. It's the *combination* of light weight and strength that makes magnesium the choice for countless applications throughout industry.

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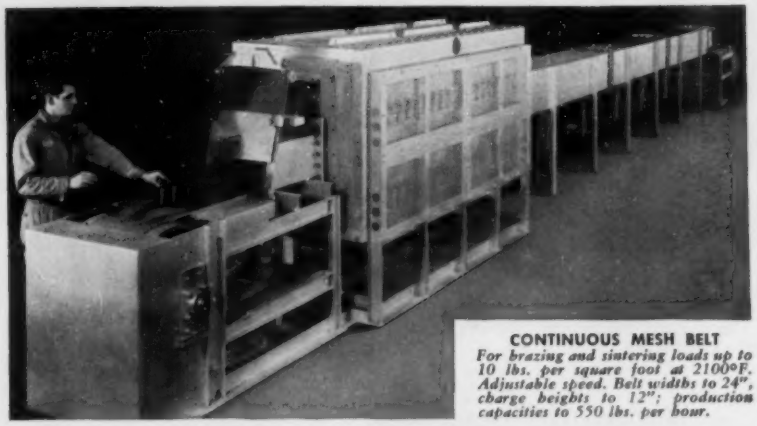

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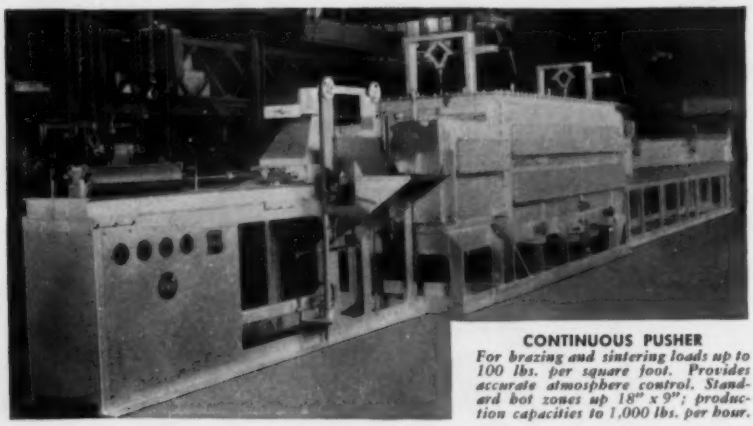

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Once the desired conditions have been established, you will obtain complete product uniformity. Conditions outside the furnace being equal, your brazed joints or sintered compacts will be identical hour after hour, week after week.

You will get up to 50% higher production from a Harper Electric Furnace with silicon carbide elements* than from comparable size furnaces using other elements. Another important advantage of these high-power elements is that they can be replaced in an emergency without complete shut-down.

Consider the brazing or sintering furnace designed for production. Write for further information today to Harper Electric Furnace Corp., 40 River Street, Buffalo 2, New York.

*Nickel chromium elements also available for lower temperature changes.

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Coatings for Steel . . .

case containing about 60% Al. For most applications, this is too high a concentration since the alloy is quite brittle and spalls on heating. Generally, an additional diffusion treatment is given to lower the Al concentration to around 25%. It should be borne in mind that extensive diffusion from long service may affect the core properties, particularly in thin sections.

The application of chromium requires careful material selection. Carbon content strongly affects the depth of case since chromium carbide is formed. This carbide acts as a diffusion barrier so that the more carbon, the sooner the formation of an impervious case. High carbon also results in a lower oxidation rate.

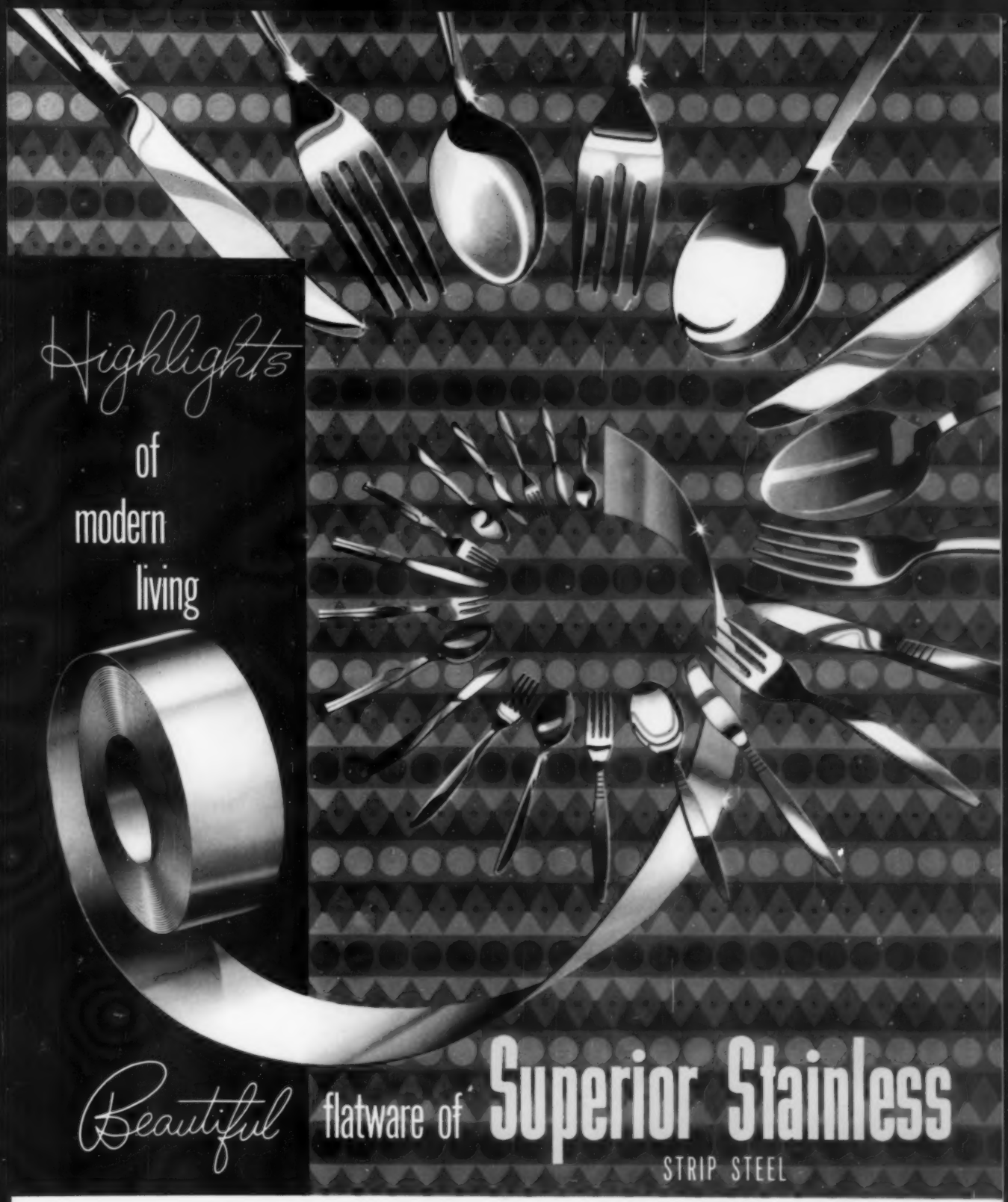
S. F. FREDERICK

Notch Ductility of Weld Metal

Digest of "Notch Ductility of Weld Metal", by W. S. Pellini, *Welding Journal*, Vol. 35, May 1956, p. 217s-233s.

THE AUTHOR presents an excellent interpretive report of the role played by the weld in affecting the ductility of weldments. Most of the experimental data presented stem from the work of the author and his co-workers at the Naval Research Laboratories. The progress in this highly complex and partially explored technical area is due, in large part, to the efforts of this group. The report is not a manual on welding practices, and was not intended as such; it is an analysis of basic principles, with the aim of providing guideposts and to stimulate further research in this field.

The scope of this report is outlined by the following list of subjects: (*a*) the general significance of notch ductility, as related to the concepts of critical transition temperatures for the initiation and for the propagation of brittle fracture, (*b*) the evaluation of specific critical transition temperatures of various types of weld metal and comparison with the critical transition temperatures of various types of base metal (all ferrous materials),



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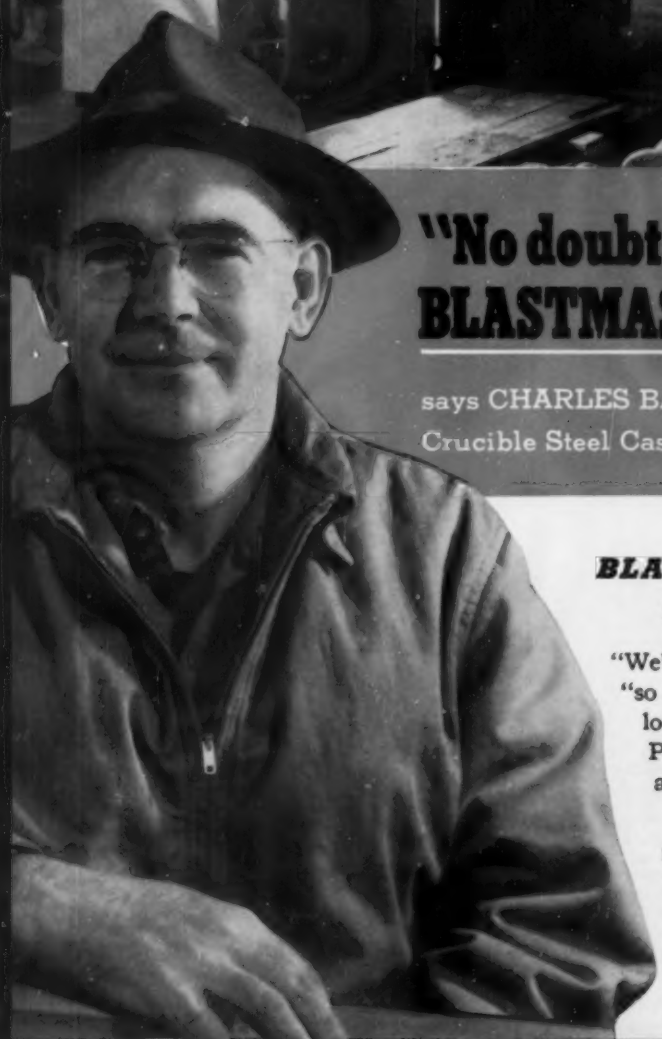
Notch Ductility . . .

(*c*) the conditions which determine the path of propagation of fracture in weldments, (*d*) the conditions which determine the point of initiation of fracture in weldments.

The concept of two types of transition temperatures – namely, one for the initiation of brittle fractures and another higher temperature for the brittle propagation of fractures – has been discussed repeatedly. The author gives his operational definitions of these two temperatures by describing the tests which are performed to establish the "Nil Ductility Transition Temperature" (NDT) and the "Fracture Transition Temperature for Elastic Loading" (FTE), corresponding respectively to the two concepts mentioned above. It is then shown how these transition temperatures can be determined by standard Charpy V-notch and Charpy keyhole tests. The significance of conventional notched-bar test data is established by means of the empirical correlation with service failure and tests on large specimens, and it is this correlation which is a major contribution to the brittle fracture problem from a practical point of view.

It is axiomatic that brittle fracture will not propagate if there is no initiation. However, from an engineering standpoint, one must assume that in or near welds, crack-like flaws develop for a variety of reasons and thus sites for initiation of brittle fractures are always present. This means that the designer must specify steel with its FTE temperature falling below the lowest temperature of service in order to eliminate the possibility of propagation of brittle fractures.

These ideas are extended to include not only the base metal but also the weld metal and the heat-affected zone. Charpy V-notch curves presented for many weld metals and weld conditions are compared to similar curves for the steels used as base metals. It is shown that the brittle fracture path will follow the weld only if the NDT of the steel is well below the NDT of the weld. If the NDT of the steel and weld are known, it is always possible to judge in advance if weld or plate fracture or both are possible in explosion bulge tests at specific temperatures. (*Cont. on p.* 148)



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Notch Ductility . . .

Sites of initiation of fracture are discussed in some detail and the role of the weld in providing such sites is pointed out. The weld, being a cast metal, always contains microscopic flaws which may be exploited by the fracture initiation process.

The notch ductility of the weld is an important aspect of this process; low notch ductility will favor a crack-starting action, while high notch ductility will act to suppress this process.

In order to use notch ductility concepts in welded design it is necessary to esablish the critical transition temperature of both the steel and the weld metal. For example, E 6010 welds are categorized by NDT in the range of −10 to +20° F., and E 10015 and E 12015 welds by NDT in the range of −70 to −50° F. Obviously, the use of a −60° F. NDT weld metal with a +40° F. NDT steel is not justified on economic grounds, while the opposite case would be highly undesirable on engineering grounds.

Ductility as discussed in the report may only be one of many factors to be considered in the evaluation of weldments but it may very well be the most important for applications which may encounter cold weather.

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Pyrometry Applied to Rolling of Uranium

Digest of "Development of Radiation Pyrometry Techniques for Measurement of Temperature During the Rolling of Uranium", by C. W. Ricker, H. F. Schof, and J. V. Werme, U. S. Atomic Energy Commission, NYO 3454, May 1, 1953.

THIS IS THE final unclassified report of an investigation performed under contract to the Atomic Energy Commission for the purpose of developing suitable techniques for measurement of temperature during hot rolling operations on uranium. The work was divided into three parts: Part One was concerned with the investigation of performance characteristics of a proprietary miniature radiation pyrometer, and also with the investigation of the emittance and emissivity of uranium rods and billets under controlled conditions. Part Two was concerned with the application in experimental rolling operations of information obtained in Part One. Part Three covered the development of special equipment to permit use of the miniature radiation pyrometer in routine rolling operations.

In order to measure the temperature of a surface by optical methods it is necessary to know the emittance of the surface. Emittance is defined as the ratio of the rate of emission at a given temperature of radiant energy from the surface in question to the rate of emission from a black body at the same temperature. A black body is a hypothetical substance that radiates the maximum amount of energy possible at a given temperature. Emittance, therefore, varies from 0 to 1.

Another term frequently used is emissivity. Emissivity is an inherent property of a material, whereas emittance is controlled by surface conditions. Emissivity is defined as the ratio of the rate of radiant energy emission of a given material to that of a black body when both are at the same temperature. The term, gray body, is also used in work of this type. A gray body is defined as a surface or device that radiates a definite fraction of the energy of a black body. This fraction does not vary with temperature.

In this investigation it was known that the emittance of a composite

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body consisting of uranium coated with oxide and molten salt mixtures would be affected by numerous factors such as the type and thickness of oxide layer, surface roughness, and the transparency and thickness of the molten salt coating. These were the factors to be evaluated and correlated in terms of their effect upon emittance. Following are some specific results from experiments designed to provide the desired information.

1. Variation in emittance with temperatures. It was concluded that the emittance of the salt-coated uranium bars did not change appreciably with temperature in the range between 900 and 1200° F. The specimens were smooth machined prior to immersion in the salt bath for heating. The maximum deviation from theoretical behavior was about 15 to 20° F., usually at the low end of the range where the salt froze.

2. Effects of oxide layer on radiation output. A somewhat anomalous result was obtained in this experiment. The recorded radiation output from a machined surface was found to be considerably greater than that from a thickly oxidized surface on the same uranium specimen. The difference in output between the two surfaces is not readily explained, although it is stated that some of the difference may have been due to an insulating effect caused by the oxide, and some to errors in temperature measurement.

3. Effect of salt thickness on radiation output from aluminum specimens. The emittance of the salt-coated surface was found to increase with an increase in salt thickness up to a certain thickness and then to decrease with further increase in thickness. A maximum emittance was reached for thicknesses of 0.085, 0.100 and 0.090 in. for temperatures of 900, 1000 and 1100° F. respectively. The maximum emittance in each case was on the order of 0.85. When contaminated or dirty salt was substituted for the clean salt in a similar experiment it was found that the dirty salt had a slightly higher emittance (0.87).

4. Emittance of oxide-coated uranium surfaces as a function of temperature. Emittance values on oxidized specimens between 0.80 and 0.84 were observed in the temperature range 1025 to 1300° F. While this amount of fluctuation was not considered significant because of the difficulty of obtaining reproducible surfaces, it was of considerable interest to note that the oxide surface had emittance values so close to those of the salt-coated specimens. This would minimize the need of distinguishing between the two types of surfaces during rolling operations.

5. The emissivity of uranium. Considerable difficulty was experienced in obtaining a clean surface due to the strong affinity of uranium for all but the noble gases. At 100 μ vacuum, with rapid heating, the emissivity up to 600° F. was observed to be around 0.15 ± 0.03. Above 600° F. oxidation proceeded too rapidly to determine emissivity of the unoxidized surface.

W. W. Austin

Aluminum heat exchanger parts are fluxed and brazed at the same time in this 50KW Ajax salt bath furnace. Located at the Trane Company, LaCrosse, Wisconsin, the Ajax furnace brazes completed units in a matter of seconds.

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Tool Steel Topics

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

New Equipment, With Die of Lehigh H, Ups Production of Cabinet Parts 200 Pct

The F. H. Lawson Co., Cincinnati, maker of bathroom cabinets, recently increased production of body blanks about 200 pct by installing a high-speed notching and cut-off operation, which is automatic from the coil to the body blank. It includes a 20-piece die, made of Bethlehem Lehigh H tool steel which had been supplied by Solar Steel Corp., Cincinnati.

In the new setup, a decoiler pulls 20-gage steel stock through the stretcher leveler into the Lehigh H die, where it is notched and blanked at about 50 strokes per minute. The die, hardened to Rockwell C 61, passed its first five months of service without any need for redressing.

Lehigh H is an ideal tool steel for blanking jobs and other severe applications, because of its wear- and shock-resistance, plus its high compressive strength. Lehigh H is our special-purpose high-carbon, high-chromium grade of air-hardening tool steel.

TYPICAL ANALYSIS

Carbon 1.55	Molybdenum 0.80
Chromium 11.50	Vanadium 0.40

There's probably more than one application in your shop where Lehigh H tool steel could do a real job. Why not try it? All you need do is get in touch with your local Bethlehem tool steel distributor.

BETHLEHEM TOOL STEEL ENGINEER SAYS:

Grinding Cracks Not Always Fault of Grinder

As a rule the grinding cracks which sometimes appear during the finish-grinding of hardened tools are attributed to improper grinding practice. They can be caused by:

1. Scorching by removing metal too rapidly.
2. Dull or loaded grinding wheel.
3. Too fine a grit size.
4. Ineffective use of coolant.

But grinding technique is not always to blame. For example, a tool which has not been adequately tempered after quenching, or one that has become embrittled by an excessively high quenching temperature, may be impossible to grind without cracking, regardless of the care used in grinding.

Unless the cause of the cracking is obvious, we recommend a complete investigation. Once the source of the trouble is known, it's easy to specify the cure.

CARBON WATER-HARDENING ECONOMICAL IN HEADING DIE STEEL

This heading die is being finish-ground prior to manufacture of 5/8-in. diam button-head track bolts. Hardened to Rockwell C 60, and working on C 1016 steel, it can produce about 100,000 pieces between grinds. Bethlehem Carbon Water-Hardening steel has high shock-resistance, and its controlled carbon range gives it ability to withstand the effects of wear and cold-battering. When used in cold-heading applications, the correct degree of hardenability must be supplied.

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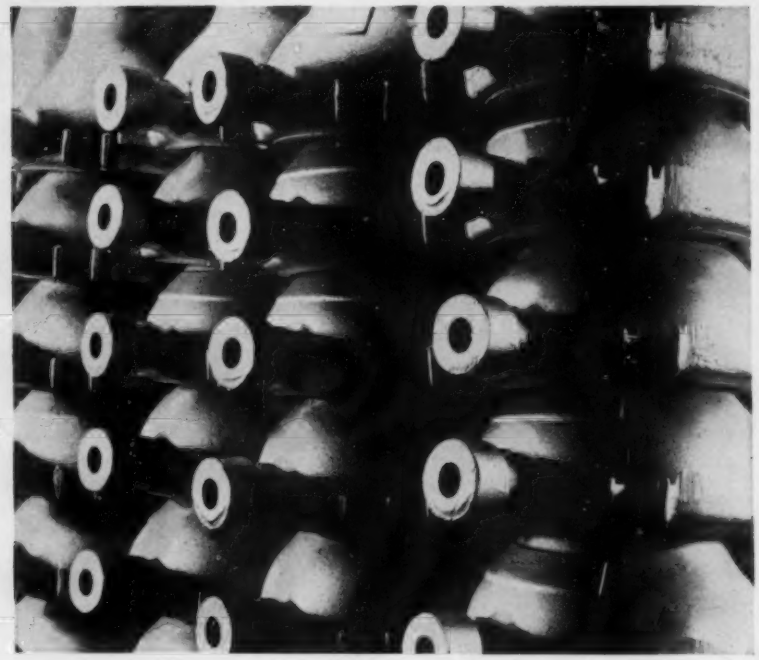

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Effect of Composition of an Aluminum Casting Alloy

Digest of "The Effect of Composition on the Mechanical Properties of Al-Si-Cu-Mg Casting Alloys", by M. G. Gittins and W. E. Mew, *Metallurgia*, Vol. 54, August 1956, p. 71-76.

THE ALLOY LM 4 (British Specification B.S. 1490 – 2 to 4% Cu, 0.15% max. Mg, 4 to 6% Si, 0.8% max. Fe, 0.3 to 0.7% Mn, 0.3% max. Ni, 0.5% max Zn, 0.1% max. Pb, 0.05% max. Sn, 0.2% max Ti, remainder Al) is one of the most widely used aluminum casting alloys in the United Kingdom. It is generally produced from scrap aluminum such as sheet cuttings, section scrap borings, and turnings. During recent years, however, wrought aluminum production has changed from copper-bearing alloys to copper-free alloys usually of higher magnesium contents. This change has increased the cost of the LM 4 alloy produced from scrap since magnesium has to be removed and copper added. To make best use of scrap from wrought aluminum products an investigation was made of the effect of adjustment of the composition on the properties of the LM 4 casting alloy.

The effect of varying copper and magnesium additions, both separately and together, on a 5 to 6% silicon alloy made from primary aluminum of 99.5% purity was analyzed. Since the silicon content was not influenced by the type of scrap available, the percentage of silicon was maintained at 5.8%. The variations tested contained 0.3% iron, 0, 1.0 and 4.0% copper, and 0, 0.15, 0.35 and 0.60% magnesium. A composition containing 0.5% copper and 0.35% magnesium was also tested.

Sand and chill-cast test bars were subjected to tensile elongation and bend tests in the as-cast condition, within 4 hr. of casting, after four weeks natural aging, and after precipitation heat treatment (16 hr. at 320° F.).

The melting, casting and stripping of the test bars was carefully standardized and controlled, so that any effects such as the rate of cooling after solidification, which may affect precipitation processes in the alloys,

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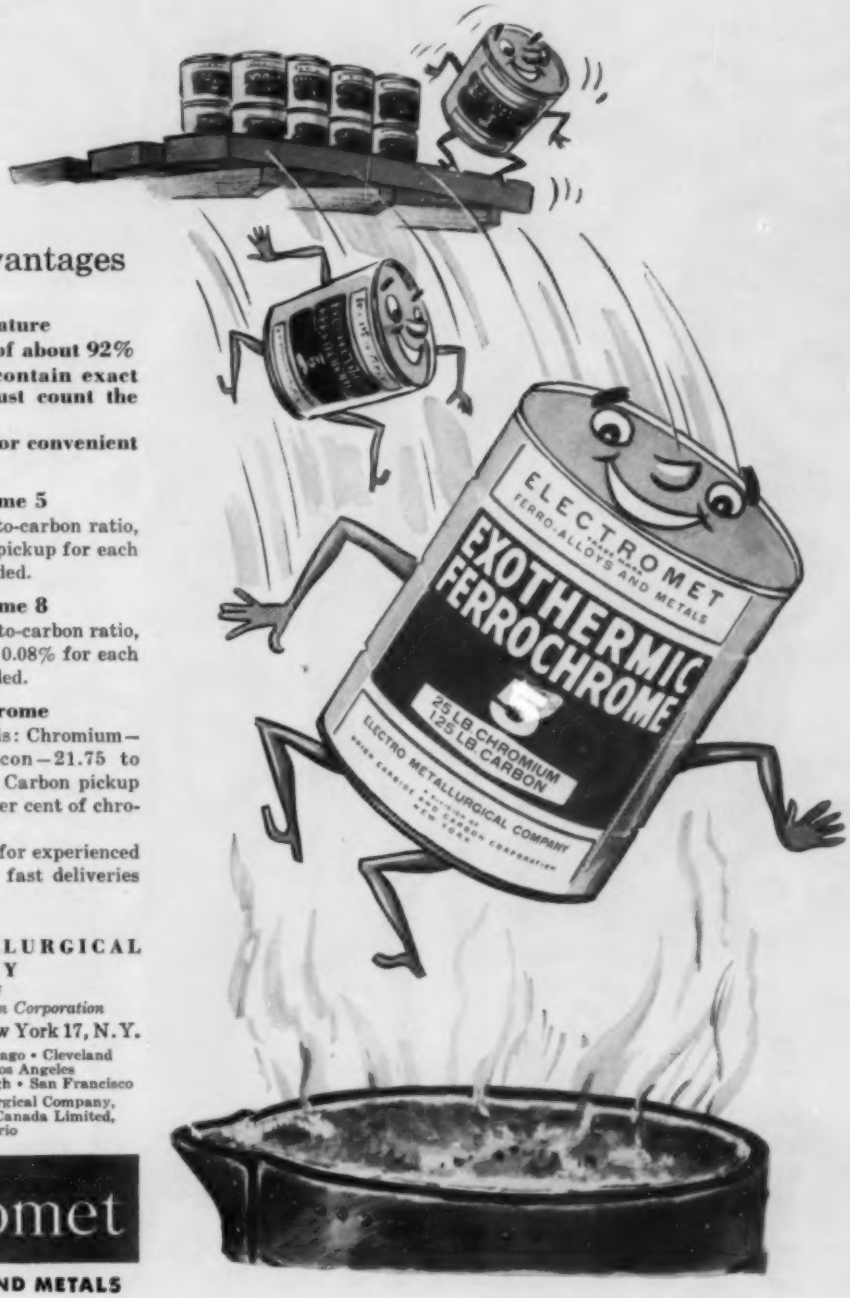

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- **palletized shipment for convenient handling**

Exothermic Ferrochrome 5
Has a 20 to 1 chromium-to-carbon ratio, gives only 0.05% carbon pickup for each per cent of chromium added.

Exothermic Ferrochrome 8
Has a 12.5 to 1 chromium-to-carbon ratio, gives a carbon pickup of 0.08% for each per cent of chromium added.

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Has the following analysis: Chromium—41.50 to 44.50%; Silicon—21.75 to 24.75%; Carbon—0.70%. Carbon pickup is only 0.016% for each per cent of chromium added.

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Centrifugally Cast

. . . of Duraloy HH Alloy, one of the most widely used high chrome, medium nickel alloys.

Two items concerning these furnace rolls may be of particular interest:

a—the size: 20 feet long—14" OD, ¾" wall thickness

b—*welding operations* by which reducing cones and shafts (both statically cast of the same alloy) were welded to the centrifugally cast rolls

These two items will serve to emphasize two phases of our service: (1) the large size centrifugally cast tubes we are able to produce and (2) our machining and finishing facilities, including welding.

Our new 16-page general Bulletin — 3354-G — gives complete details. Would you like a copy? When writing or calling would you mind telling us the general nature of your high alloy casting requirements? Better yet, if you have specific requirements on which we could help, let us have the details.

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OFFICE AND PLANT: Scottdale, Pa.

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Al Casting Alloy . . .

would be reproducible and constant in each test bar.

The results of the mechanical tests were given as the average of three or four test bars. Test bars which showed any evidence of inclusions or other faults were discarded.

A survey of the results showed the following:

1. There is a definite deterioration in the tensile strength of both naturally and artificially aged specimens, as the magnesium content exceeds about 0.3% in alloys containing more than 1% copper.

2. The elongation falls regularly with increasing additions in all tests, whereas for maximum tensile strength there is an optimum magnesium content which depends to some extent on the copper content. This is very pronounced in all aged specimens.

3. Natural aging has a detrimental effect on the elongation of alloys in the range of more than 1% Cu and between 0.1 and 0.35% Mg. Artificial aging reduces the elongation of alloys having lower copper content.

4. The addition of the first 0.15% of magnesium has more effect than subsequent additions, especially in the chill cast bars. Copper also has more effect in the lower range but is still effective up to about 4%.

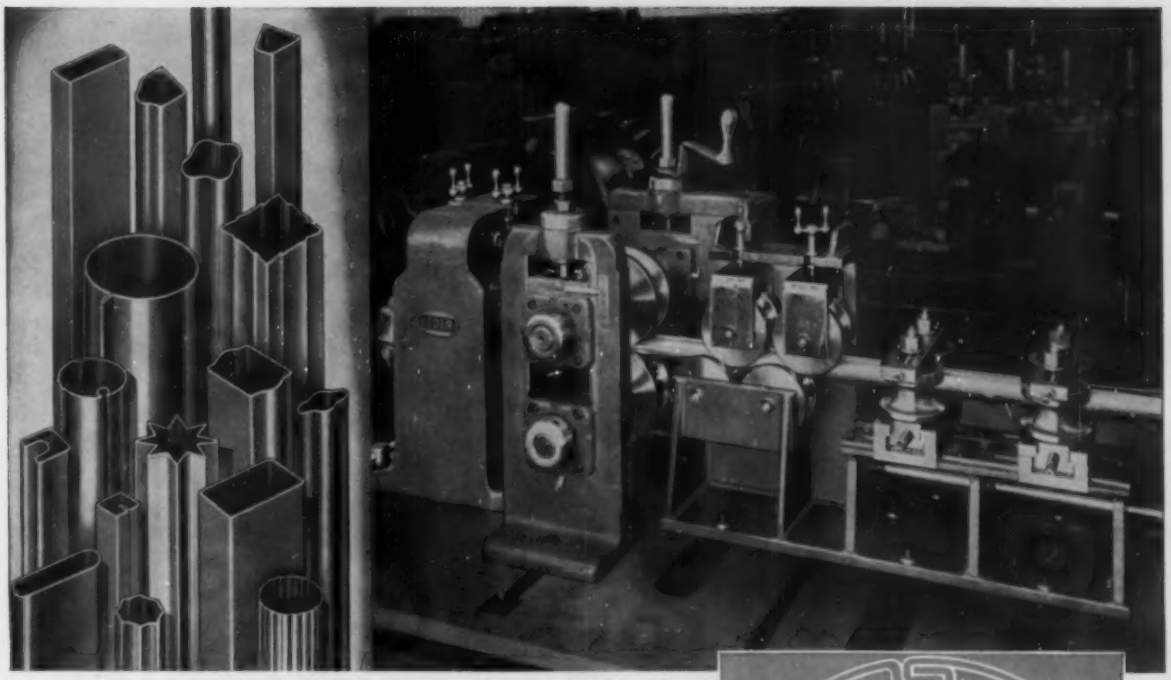
5. The influence of hardening elements (magnesium and copper) in increasing the tensile strength is greater in chill cast bars than in sand cast bars.

6. The change in properties produced by precipitation heat treatment is greater in sand cast bars than in chill cast bars.

The authors present their results in graphical form by plotting contour graphs showing the effect of increasing copper and magnesium content on the mechanical properties. Based on these graphs the following conclusions were drawn:

1. If the copper content of the LM 4 alloy were reduced to approximately 1%, a range of composition could still be found which would give the mechanical properties within the LM 4 specification.

2. The practical top limit for magnesium when both copper and silicon are present is approximately 0.3% if mechanical properties simi-



Lock-Seaming attachment at exit end of forming machine.

COLD ROLL FORMING TUBULAR SHAPES

Among the wide variety of things you can make on a Yoder Cold Roll Forming machine are round, square, oval, rectangular and other tubular shapes, such as illustrated at left above. The seams may be open, lapped, butted, dovetailed, interlocking, etc.—as indicated in Figures 1 to 6 at the right.

Millions of feet of such unwelded tubular shapes are made from coiled strip for conductor pipe, bedsteads, lamp stands, window channel, wiring raceways, carrying rods, etc. Production ranges from 20,000 to 50,000 feet per day, with only one operator and a helper.

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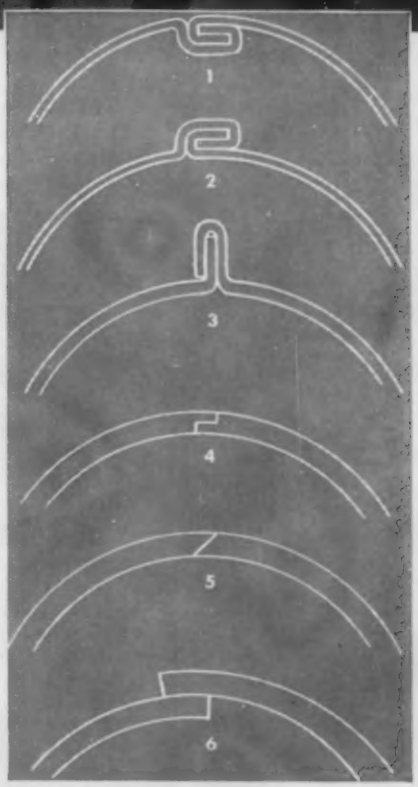
The Yoder book on Cold Roll Forming is a complete, illustrated text on the art and the equipment needed for performing a variety of operations which can be combined with cold roll forming, at little or no extra labor cost. A copy is yours for the asking.



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Al Casting Alloy . . .

lar to the LM 4 are desired without heat treatment.

3. Age hardening is a normal characteristic of all these alloys except where copper and magnesium are very low.

4. The effect of natural aging is to reduce the effective range of copper and magnesium within which the specified mechanical properties of LM 4 can be obtained when considering castings for practical use.

W. A. MORGAN

Effect of Drawing Compound on Flash Welds

Digest of "The Effects of Zinc Phosphate Coating on Flash Welding of Steel Tubing", by J. F. Young and A. Phillips, *Welding Journal*, Vol. 35, September 1956, p. 416s-420s.

IN CRITICAL APPLICATIONS where flash welded components must exhibit consistently high quality, brittle bend test failures have led to a study of the effects of tube drawing compounds on flash welds. Fractures having flat breaks and no evidence of normal flash weld defects are attributed to residual phosphorus from drawing compounds.

Radioactive isotope studies, notch-bend, tensile, and Charpy impact tests, and microscopic examinations were used to investigate the effect of zinc phosphate coating. Samples were prepared from S.A.E. 8630 tubing, some of which were welded as received, and some of which were machined on both the ID and OD to remove residual drawing compound before welding.

After welding, the weld area was spot-checked for zinc. Zinc was found on unmachined specimens, but not on those which were machined. This indicated vaporization of zinc from the residual coating during welding. After surface checking, all samples were prepared for mechanical testing.

Tensile specimens were all heat treated to 180,000 to 200,000 psi. and the flash removed flush with the OD of the tube. Notch-bend test and metallographic specimens were prepared from two groups. One group was heat treated and one was as-welded. Notch-bend specimens

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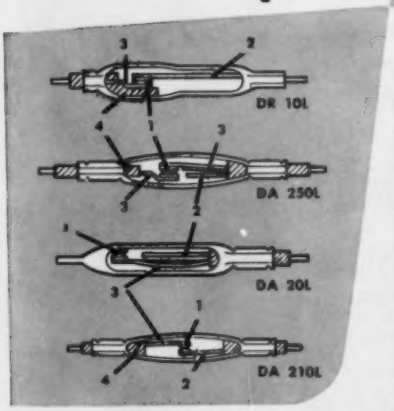
How CHACE Thermostatic Bimetal Actuates the FRANKLIN DALES Temp-Guard



The Temp-Guard is an extremely compact, self-contained and sealed tubular type circuit breaker manufactured by The Franklin Dales Co. Numerous variations of standard models are used in applications such as electric motors, operating on-off cycling systems, detecting fire and activating alarms, protecting electrical appliances, controlling regulating systems, automatically making or breaking current to solenoids, transformers, etc. The accuracy and dependability of this interesting device hinge upon its actuating element of Chace Thermostatic Bimetal.

The photo shows a typical Temp-Guard actual size. Others vary from 1 5/16" to 3 3/8" in length. The sectional drawings show four representative types of circuits; the DR models have the thermostatic bimetal element in contact with the case; the DA models have element insulated from the case. The numeral "2" indicates that case does not carry current. Parts numbered in the drawings are:

1. Contacts
2. Thermostatic Bimetal Element
3. Conductive Strip
4. Insulation

In all examples, the bimetal element deflects in response to changes in ambient temperature or heating of the element due to overload, making or breaking the circuit.

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Drawing Compounds . . .

were machined so that 0.020 in. of the flash remained and a 0.040-in. sharp V-notch was in the center of the weld. The tube specimens were filled with a low-melting alloy to prevent crushing and loaded as simple beams with a 5-in. span. Impact specimens were not made from tubing. Bars of S.A.E. 4130 steel were machined to standard Charpy specimens. Half of the impact specimens were coated with zinc phosphate and half left clean. They were then heated by resistance in a flash welder to simulate a welding treatment.

Tensile tests on welded and heat treated tubing failed to show any significant variation attributable to the presence of a zinc phosphate coating. Notch-bend tests on welded and heat treated tubing indicated no lowering of strength, but the notch-bend strength of as-welded tubing was less. The Charpy V-notch impact transition temperature range was higher due to the presence of zinc phosphate coatings. Metallographic studies of all the specimens failed to reveal anything unusual in the weld zone of either the coated or the machined specimens.

Surface machining of zinc phosphate coated tubing revealed that phosphorus diffused to a depth of 0.008 in. At this depth, chemical analyses showed 0.012% phosphorus or twice the amount specified for this composition of steel.

To establish the mechanism by which zinc phosphate causes embrittlement of steels, phosphorus-32 as phosphate in weak hydrochloric acid was added to a proprietary zinc phosphate compound prior to drawing. Samples were flash welded from tubing coated with the tagged phosphorus. The fumes showed no radioactivity, but the weld spatter was strongly radioactive even after cleaning in a strong caustic. Welded tubing drawn with compounds tagged with phosphorus, machined and wrapped with film strips showed that most of the phosphorus was concentrated within 0.05 in. on either side of the weld.

To determine the role of zinc from the drawing compounds, zinc-65 was added to the zinc phosphate solution. The same procedure used for phosphorus indicated that a

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Picker X-Ray Corporation and Holger Andreasen, Inc. are pleased to announce that, effective April 1, 1957, all Andrex equipment for industrial radiography will be distributed and serviced in the United States exclusively by Picker X-Ray Corporation.

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Drawing Compounds . . .

large portion of the zinc went off in the fumes and that which remained was concentrated on the extreme surfaces of the tubing.

Chemical cleaning either with hot caustic (200° F.) or a 5% sulphuric acid solution prior to normalizing at 1300° F. completely removed the ill effects of residual phosphorus. If, however, the heat treatment precedes cleaning, brittle flash welds result.

The results of this work show that brittle joints may result when flash welds are made in steels which have been lubricated with zinc phosphate compounds during forming. Phosphorus lowers the notch-bend strength and causes flat breaks through the weld. The Charpy V-notch impact transition range is displaced to higher temperatures by phosphorus in flash welded joints.

Heat treatment subsequent to flash welding will remove the effect of phosphorus contamination. Cleaning in caustic or sulphuric acid prior to welding and heat treatment will also remove the effects.

Zinc from drawing compounds does not enter the flash welded joint. It either volatilizes or remains on the surface of the work.

R. EVANS

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Machinability of Iron and Steel

Digest of "The Present State of Our Knowledge Concerning the Machinability of Iron and Steel", by F. Rapatz and F. Motalik-Kapfenberg, *Stahl und Eisen*, Vol. 76, April 19, 1956, p. 477-485.

MANY FORMULAS previously used to measure the machinability of alloy and plain carbon structural steels are not applicable today. Various criteria of tool life such as cratering and wear of the free surface do not offer practical solutions, and ultimate tensile strength is no longer a valid measure of machinability. A universal attack for this problem is yet to be found.

The depiction of tool wear as a series of straight lines drawn on a double logarithmic scale is an oversimplification which can lead to excessive errors. The wear characteristics of carbide-tipped tools are influenced by structural changes which take place at high temperatures. Electrochemical processes also play an important part. In addition to mechanical wear there is also the problem of chemical wear to contend with. Knowledge of the mechanical and chemical wear processes needs to be extended.

The use of radioactive tools and the Geiger counter to measure eroded tool material is a noteworthy new method being investigated.

The effect of microstructure on machinability is not fully understood. For alloyed and hardened steels coarsely lamellar pearlite is best as far as machinability is concerned. In high-carbon steels spheroidal or globular cementite is always desirable.

Carbide tips are improved by the addition of tantalum. In high speed steels the use of molybdenum shows promise.

R. C. SHNAY

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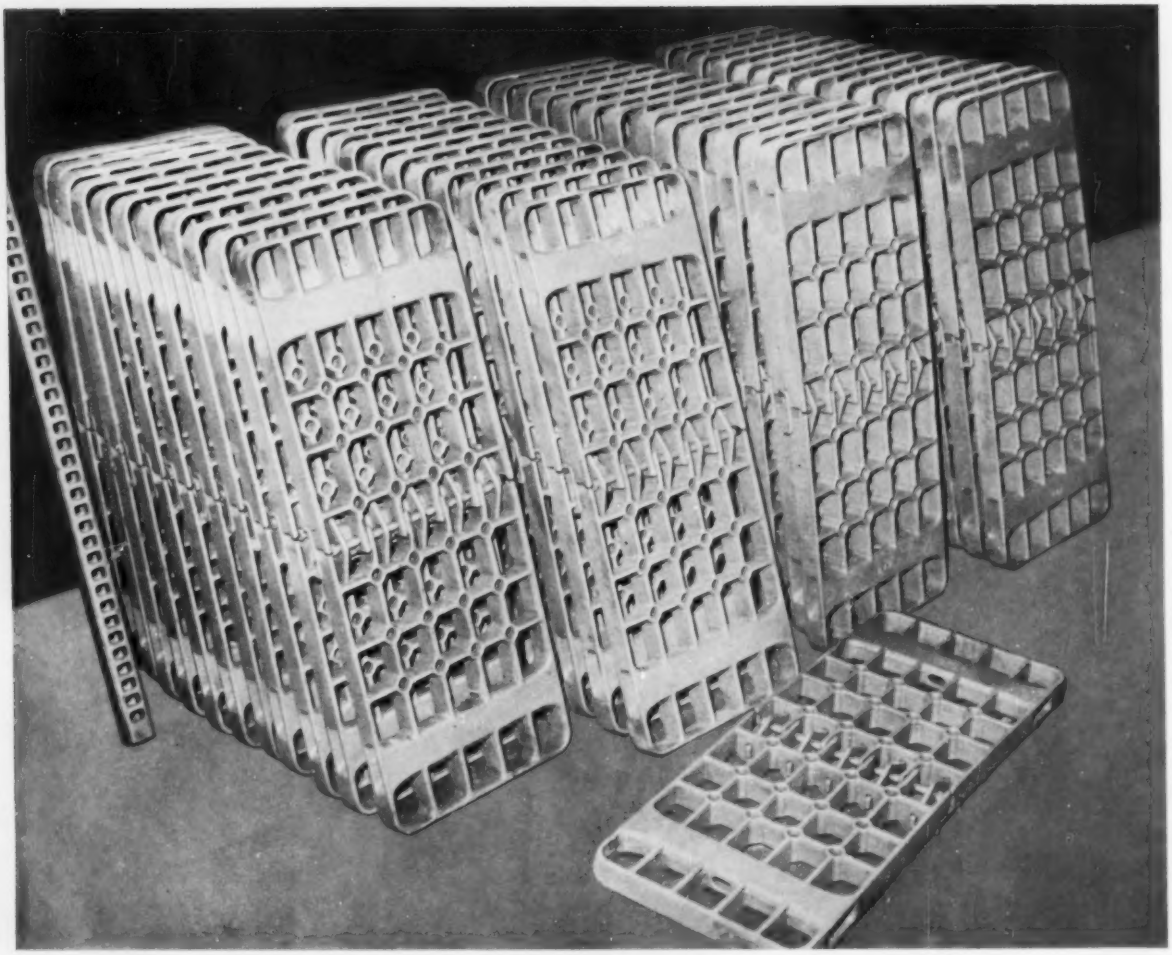

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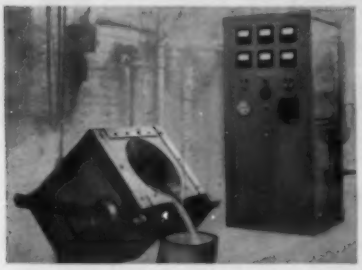

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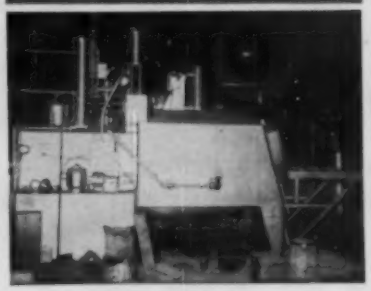

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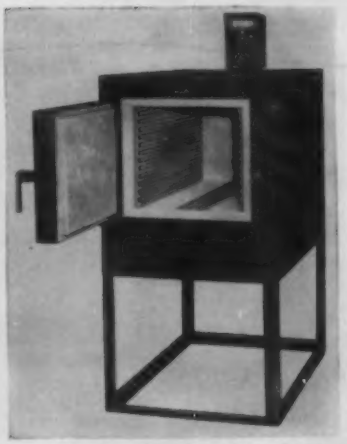

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P918	9"x9"x18"	$480.00	$528.00
P414	14"x14"x14"	$525.00	$603.25
P124	12"x12"x24"	$715.00	$822.25
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P136	18"x18"x36"	$1125.00	$1312.50

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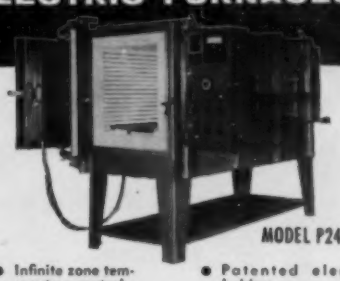

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Photomicrograph shows diffusion structure of the CHROMALLOY Case. At the surface the chromium content is 35% to 45%.

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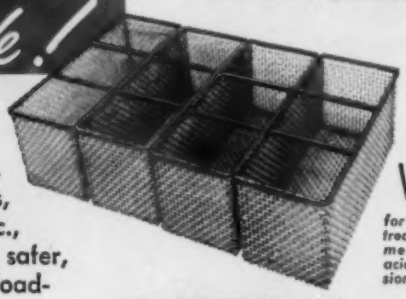

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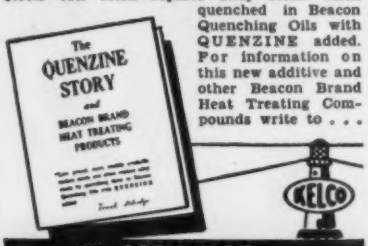

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Determines the initial, basic stiffness or resilience of sheet and wire specimens, including cellophane and metal foil. Eight test ranges provide wide application, up to 100X. Test length, angle of deflection, rate of loading all standardized for accurate results between laboratories. Scale calibrated in gram centimeters.

TABER Abrasion TESTER

Tests wear resistance of metal, plastic, paint, rubber, leather, paper, foil, etc. With average technical experience, anyone can make a scientific, comparative abrasion resistance test with this instrument.

Write for Illustrated Literature.

TABER INSTRUMENT CORPORATION
SECTION 19
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MULTI MOTION DIES* . . . .
FOR TEST SPECIMENS . . .

- Tensile Bars
- Transverse Bars
- Green Strength
- Bushings
- Slugs
- Stepped Parts

DL-1001 TENSILE TEST BAR MPA STANDARD 10-51

Complete design facilities for dies or subpress units to press unusual shapes in lab presses.

*PATENTS PENDING

HALLER, INCORPORATED
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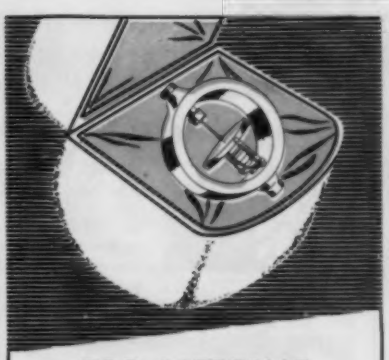

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In industry's showcase, accuracy means top quality . . . accuracy in both equipment and product.

Accurate force measuring and weighing equipment brings a top price in the industrial market and you who use this equipment pay the price willingly, because you have built your business on accuracy.

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NEW "A-B-C" BOOKLET AVAILABLE

The most practical handbook on force measuring system accuracy available today is yours for the asking. Write for it right away.

MOREHOUSE MACHINE CO.
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HARDNESS TESTING
SHORE SCLEROSCOPE

Pioneer American Standard Since 1907

Available in Model C-2 (illustrated), or Model D dial indicating with equivalent Brinell & Rockwell C Hardness Numbers. May be used freehand or mounted on bench clamp.

OVER 40,000 IN USE

SHORE INSTRUMENT & MFG. CO., INC.
90-35M Van Wyck Exp., Jamaica 35, N.Y.

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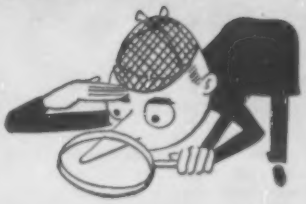
FREE
Listing Service for Used Equipment



Mr. Buyer—
LOOKING FOR USED EQUIPMENT?

This new service on used heat treating equipment is completely without obligation to you. To receive the latest availabilities just drop us a line requesting to be placed on our mailing list for a monthly digest. What are your production requirements?

Mr. Seller—
WITH EQUIPMENT TO SELL!

Take advantage of the opportunity to list useful, but no longer needed used heat treating equipment. Send us details including manufacturer, type, size, capacity, original and asking price. Monthly digest will be mailed to all listed firms.

ANOTHER HOLDEN SERVICE

This free listing is yours at no cost. CHECK WITH HOLDEN FIRST. Proven MONEY MAK-ER PRODUCTS.

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MANUFACTURING PLANTS
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LOS ANGELES, CALIF. (LUdlow 1-9153)
NEW HAVEN, CONN. (STate 7-5885)

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Inspection Demagnetizing or Sorting PROBLEMS?

SOLVED with

MAGNETIC ANALYSIS MULTI-METHOD EQUIPMENT

Electronic Equipment for non-destructive production inspection of steel bars, wire rod, and tubing for mechanical faults, variations in composition and physical properties. Average inspection speed 120 ft. per minute.

Over 80 installations in steel mills and fabricating plants.

MAGNETIC ANALYSIS SPECIAL EQUIPMENT

Electronic Equipment for non-destructive production inspection of both non-magnetic stainless and high temperature steel bars and tubing—seamless or welded—as well as non-ferrous bars and tubing. Mechanical faults, variations in composition and physical properties are detected simultaneously. Average inspection speed 200 ft. per minute.

Over 30 installations in mills and fabricating plants.

MAGNETIC ANALYSIS COMPARATORS AND METAL TESTERS

Electronic Instruments for production sorting both ferrous and non-ferrous materials and parts for variation in composition, structure and thickness of sheet and plating.

MAGNETIC ANALYSIS DEMAGNETIZERS

Electrical Equipment for rapid and efficient demagnetizing of steel bars and tubing. When used with Magnetic Analysis Multi-Method Equipment, inspection and demagnetizing can be done in a single operation.

MAGNETIC ANALYSIS MAGNETISM DETECTORS

Inexpensive pocket meters for indicating residual magnetism in ferrous materials and parts.

TRADE MARK

For Details Write:

MAGNETIC ANALYSIS CORP.

42-44 Twelfth St., Long Island City 1, N. Y.

"THE TEST TELLS"

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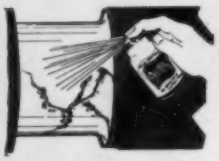
DYELINE INSPECTION PROCESS



Dyeline—a new two-stage inspection process for all non-porous materials. No skilled operator or expensive equipment necessary! Just spray Dyeline, follow with Dyeline Detector, and the exact location, type and extent of defects appear sharply and clearly on an opaque background! No solvent required—water removes Dyeline immediately.

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1360 W 9th St. • Cleveland 13, Ohio

ALSO:

ZIP SPEED LACQUER—Identifies all materials with a quick color-coding process.

ZIP RUST STOPPER #1 Protects metal parts for storage.

ZIP RUST STOPPER #2 Protects parts left in machinery for further processing; removes fingerprints.

ZIP PATTERN LAYOUT FLUID—Shows up scribed patterns strongly.

ZIP STENCIL INK—Quick drying—excellent on cartons and metals.

ZIP BELT LUBE—Prolongs belt life; promotes safety and speed.

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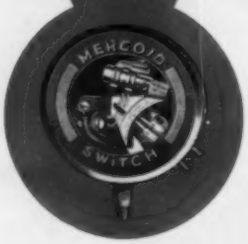
TEMPERATURE PRESSURE LIQUID LEVEL



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"The Contact That Never Requires Cleaning"

FOR OUTDOOR, INDOOR OR EXPLOSIVE ATMOSPHERES

Our engineers are at your service—send in your control problem or

Write for catalog No. 857

THE MERCOID CORPORATION
4211 Belmont Ave., Chicago 41, Ill.

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THE NEW

DERMITRON

NON-DESTRUCTIVE COATING THICKNESS TESTER

FAST—ACCURATE
COMPACT—PORTABLE
DIRECT-READING

- *Sorts Metals and Alloys*
- *For Metals on Metals*
- *Non-Conductors on Metals*
- *Metals on Non-Conductors*

You can now have 100% inspection of production of nearly any possible coating on almost any base—including the first and only accurate, direct readings of such combinations as zinc, cadmium, copper on steel; silver on brass; copper on zinc; anodizing on aluminum; organic coatings on non-ferrous metals — without the use of chemicals.

WRITE FOR FULL INFORMATION

UNIT PROCESS ASSEMBLIES, INC. UPA

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JELLIFF BASKETS

for ALL Industrial Uses

- Degreasing
- Anodizing
- Pickling
- Plating
- Heat Treating
- Heavy Industrial Types

ANY SIZE AND SHAPE • ANY DUCTILE METAL

Ask for Bulletin 28

THE C. O. JELLIFF MANUFACTURING CORP.

SOUTHPORT • CONNECTICUT

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ULTRASONIC

Thickness Testing from One Side

Rapid, Accurate, Non-Destructive

VIDIGAGE®

14″ or 21″ Cathode-Ray Screen with direct-reading scales between 0.005″ and 2.5″; accuracy 0.1% to 1.0%.

AUDIGAGE®

Portable Thickness Testers for ranges from 0.020″ to 4″ or 0.060″ to 12″ of steel; accuracy up to 1.0%.

Detect Laminar Flaws and Lack of Bond

BRANSON INSTRUMENTS, INC.

6 Brown House Rd., Stamford, Connecticut

Specializing in Ultrasonics Since 1946

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Solventol

ORIGINATORS OF DI-PHASE METAL CLEANING

DESIGNERS & BUILDERS OF SPECIALIZED METAL CLEANING EQUIPMENT

For Latest Information Write to:

SOLVENTOL CHEMICAL PRODUCTS, INC. • DETROIT 3, MICHIGAN

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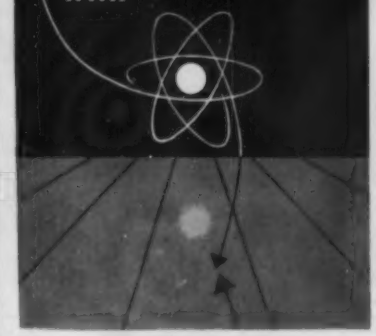
TECHNIC

equips you to Electroplate Precious Metals with



SCIENTIFIC PRECISION

Technic, Inc. equips you with controlled apparatus and electroplating solutions to maintain exacting standards and close tolerances. Typical benefits are the spectacular economies Technic effects in handling gold — where often electroplaters lose up to $60,000 or more of every $100,000 worth through outmoded equipment, inefficient methods and solutions.

TECHNIC ENGINEERING

Technic engineers design and install your equipment — and stand by until performance is assured. *No installation is complete without this follow-through.*

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Technic Potassium Gold Cyanides, Concentrated Aqueous & Dry • Technic Electroplating Solutions: Rhodium, Platinum & Palladium • Technic Immersion Tin • Technic Protectox Anti-Tarnish • Technic Flame Flux

TECHNIC EQUIPMENT

Technic Electroplating Systems • Technic Germanium Diode Rectifiers • Technic Turbomatic Agitators • Technic Electroplating Barrel Unit • Automatic Techni Timers

TECHNIC BIBLIOGRAPHY

Technic publications, authoritative in our field: "Electroplated Gold"; "Precious Metal Electroplating Data: Gold, Rhodium, Palladium, Platinum, Silver, Nickel"; "Electroplated Platinum"; "Electroplated Palladium"; "Electroplated Rhodium"; "Analysis of Gold & Gold Alloy Solutions".

Consult us without obligation, whether in respect to a new installation and electroplating solutions, or an existing system now in use. Write for Technic publications in your field of interest.

TECHNIC, INC.

39 Snow Street,
Providence, R. I.
JAckson 1-4200
Chicago Office—7001
North Clark Street

THE LARGEST ENTERPRISE OF ITS KIND IN THE WORLD

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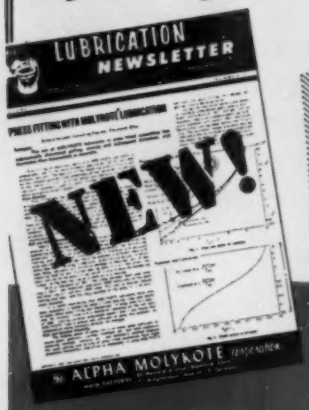
Engineering Data on MOLYKOTE® lubricants



- Being published regularly
- Every issue features a full-length technical article on the use of MOLYKOTE Lubricants in industry.
- "How-to" stories on tough lubrication applications
- Get on our mailing list TODAY. Write to

The ALPHA MOLYKOTE CORPORATION
Main Factories:
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71 Arnulfstrasse, Munich 19, Germany

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TENSILKUT
Patent Pending

Accurate test specimens machined from sheet and plate materials .0005 to .500 in., in less than 3 min.

SIEBURG INDUSTRIES, INC.
Horse Plain Rd. • New Britain, Conn.

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the GENUINE BRINELL
HARDNESS TESTING MACHINES
made by the Alpha Co. of Sweden and available from our stock at New Rochelle

Never approached in ACCURACY AND CONSTANCY of calibration . . . at the standard 3000kg test load: . . . maximum error plus or minus 2½ kg

Write for Bulletin No. A-18

GRIES INDUSTRIES, INC.
Testing Machines Division
NEW ROCHELLE 3, N. Y.

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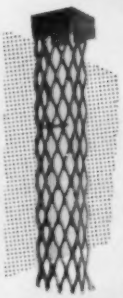
there's a Glo-QUARTZ* IMMERSION HEATER for Your Every Heating Requirement



- INSTANT HEATING
- SHOCK-PROOF
- AVAILABLE IN ALL VOLTAGES —WATTAGES, ONE AND THREE PHASE

Available from your Electroplating Distributor

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Glo-QUARTZ
ELECTRIC HEATER CO., INC., Willoughby, Ohio
*Reg. U.S. Pat. Off. Phone: Willoughby 2-5521

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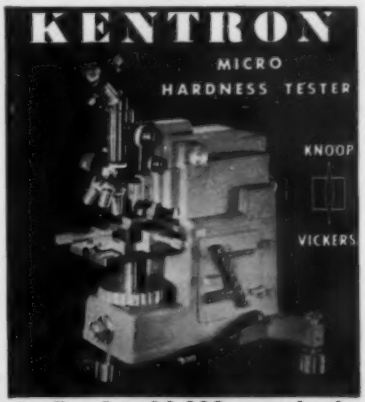
KENTRON
MICRO HARDNESS TESTER



Applies 1 to 10,000 gram loads
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Kent Cliff Laboratories Div.
The Torsion Balance Company
CLIFTON NEW JERSEY

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Meet the Sel-Rex Family of Industrial Precious Metals....

BRIGHT GOLD
Mirror-bright finish in any thickness directly from the bath.
Patent Pending

SILVREX BRIGHT SILVER
Crystal-clear solution that produces mirror-bright deposits.
Patented

BRIGHT RHODIUM
Brilliant, fine-grained, non-tarnishing deposits.

PUR-A-SALTS
Restores contaminated cyanide plating baths to full, trouble-free operation.
Patented

SILVER SOL-U-SALT
Non-dusting — safest and easiest to use.

RHODEX
Only rhodium electroplating process that yields extra heavy compressively stressed deposits.
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Sel-Rex
SEL-REX CORPORATION
Dept. BB—155 Manchester Place, Newark 4, N. J.
Offices: Detroit—Chicago—Los Angeles

Complete installation and servicing on all precious metals processes.

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Since 1923

Specialists in All Phases of METAL CLEANING EQUIPMENT

- DEGREASERS • AGITATING WASHERS • PICKLERS
- PHOSPHATIZING WASHERS • ALKALINE WASHERS
- FLOW COATING SYSTEMS • "SPOTLESS" DRYERS
- OVENS • ULTRASONIC CLEANING EQUIPMENT

We will be happy to send a sales engineer to help you with any metal cleaning equipment problem. Complete information on request.

- *CIRCO-SOLV (Trichlorethylene)*
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CIRCO EQUIPMENT COMPANY

51 Terminal Avenue, Clark, New Jersey • Pilltee 8-8600

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SPECIALISTS IN THE FIELD OF

Die Castings

SINCE 1922

Aluminum and Zinc

THE HOOVER COMPANY
Die Castings Division
North Canton, Ohio

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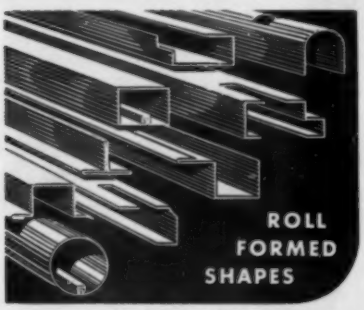

Reduce your assembly problems and costs. Our shapes continuously formed, with high degree of accuracy, from ferrous or non-ferrous metals. Write for Catalog No. 1053.

ROLL FORMED PRODUCTS CO.

MAIN OFFICE AND PLANT
3761 OAKWOOD AVE. • YOUNGSTOWN, OHIO

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make instant tests of iron content in stainless steel welds

New pocket size
Ferritic **ELCOMETER**

Answers need for rapid testing. New precision instrument shows directly on scale the per cent of Ferritic content of weld, replacing time-consuming, destructive laboratory analysis. Enables you to make rapid, on-the-spot, nondestructive tests for iron content.

Accurate readings in all positions. Needle locking device assures correct readings. Balanced in all planes. Sturdily constructed. Comes in tough leather case. Fits in pocket.

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FERRO CORPORATION

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Swift

SOLUTIONS TO YOUR METAL TREATING PROBLEMS! . . . .

SWIFT BLACK

Activanium Blended— Positive blackening of every ferrous metal and alloy!

NOT GRAY
NOT FADED
NOT MOTTLED
BUT RICH, DARK, UNIFORM
BLACK

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Liquid Carburizer— For a tougher, more durable case!

SWIFT HEAT

Liquid Salt Baths— Temperature range 300° to 2500° F. . . . no decarburization!

RUST PREVENTATIVES

Sol-u-Kote— An emulsifiable rust protective, effective even under humid conditions.

METAL CLEANING PICKLING and PLATING COMPOUNDS

Acid additives, brighteners, bright dips and chromate conversion coatings!

Send today for literature and technical data sheets.

THE Swift INDUSTRIAL CHEMICAL CO.
Canton, Connecticut

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Ask the Man Who KNOWS Stainless Welding . . .

Call Mr. Electrode . . . His years of experience and leadership in providing the correct—

Stainless and Heat Resistant Arc Welding Electrodes
—place a trusted guarantee back of your welding operations.

Automatic Welding . . .
• All Analyses
• Coated, Straightened
• Cut • Coiled and Spooled

MAURATH, INC.
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Phone: MOntrose 2-6100

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A CABLE SPLICED IN 10 SECONDS!

ERICO PRODUCTS, INC.
Complete Arc Welding Accessories
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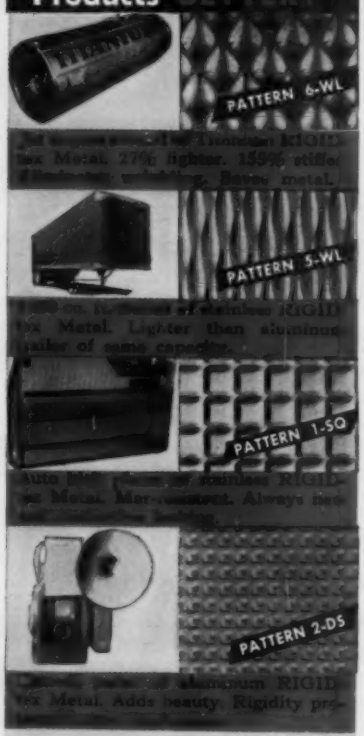
RIGID-tex METAL
Makes all these Products BETTER!



RIGID-tex Metal can make your product better too! This new catalog tells how. Copy mailed free.

See Sweet's Design File 1a/Ri or write for information.

RIGID-tex METAL
IT'S RIGIDIZED

RIGIDIZED METALS CORP.
6634 Ohio St., Buffalo, N. Y.
Representatives in Principal Cities

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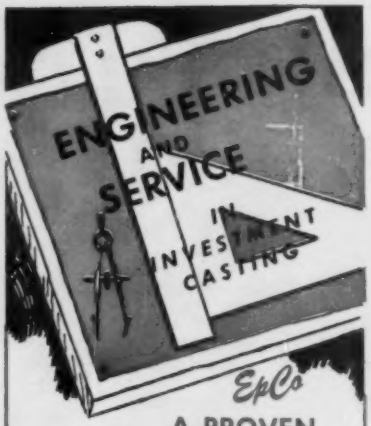

A PROVEN DEPENDABLE SOURCE
FOR BETTER GRADE INVESTMENT CASTINGS IN FERROUS AND NON-FERROUS METALS

INVAR CASTING
Special Feature — Nickel content held to 35% minimum — 36% maximum

STAINLESS STEEL PART for milk bottling unit formerly machined from solid stock. Only finish operations required are reaming small dia. of counterbored hole and drilling and tapping for set screw.

ENGINEERED PRECISION CASTING CO.
MORGANVILLE, N. J.

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DO YOU HAVE AN IDEA . . .

THAT SOME FUNCTIONAL METAL PART COULD BE MADE BETTER OR CHEAPER BY ALUMINUM EXTRUDING?

Bring your idea to specialists in adapting aluminum extrusions to new functional parts applications. G. E. I.'s engineers are ready to consult with you, without obligation, on one part or a million.

GENERAL EXTRUSIONS, INC.
4040 LAKE PARK RD., YOUNGSTOWN, OHIO

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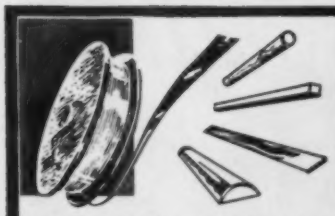

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Beryllium Copper • Bronzes
Other Non-ferrous Alloys
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Available with hot-tinned finish for solderability.
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INCORPORATED
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IN
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Grade "C-W-25"

Non-flammable
Non-toxic
Aqueous Oily Film
Protects Ferrous Parts
for Long Periods
Indoor Storage

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CORROSION RESISTANT

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Direct N.Y. 'phone Wisconsin 7-9041

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Du-Lite

CU-PREP

- No acid pickle or bright dip.
- No dimensional changes or surface damage.
- No acid drag-in. Assures stabilized blackening bath throughout longer life — more economical.

Write for full details. Du-Lite Cu-Prep is made and guaranteed exclusively by the metal finishing specialists:

Du-Lite
DU-LITE CHEMICAL CORP.
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WELDCO FABRICATED MONEL PICKLING EQUIPMENT

• Hairpin Hooks • Sheet Crates
• Steam Jets • Chain
• Mechanical Bar, Tube and Coil Picklers

THE YOUNGSTOWN WELDING & ENGINEERING CO.
3721 OAKWOOD AVE. YOUNGSTOWN, OHIO

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MAGNESIUM

your comprehensive independent mill source of magnesium alloy
Tubes • Rods • Shapes • Bars
Hollow Extrusions • Plate • Sheet
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82 Moultrie St., Brooklyn 22, N. Y.
Sales Office
376 Lafayette St., New York 3, N. Y.

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INFO-COUPON SERVICE, METAL PROGRESS
7301 Euclid Avenue, Cleveland 3, Ohio

Please send further information, as checked at the right, on the advertisements in the Bulletin Board with numbers I have listed below—

	(Please check) Send Catalog or Engineering Data	Send Price Info
_____	☐	☐
_____	☐	☐
_____	☐	☐
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Name.....
Company.....
Street.....
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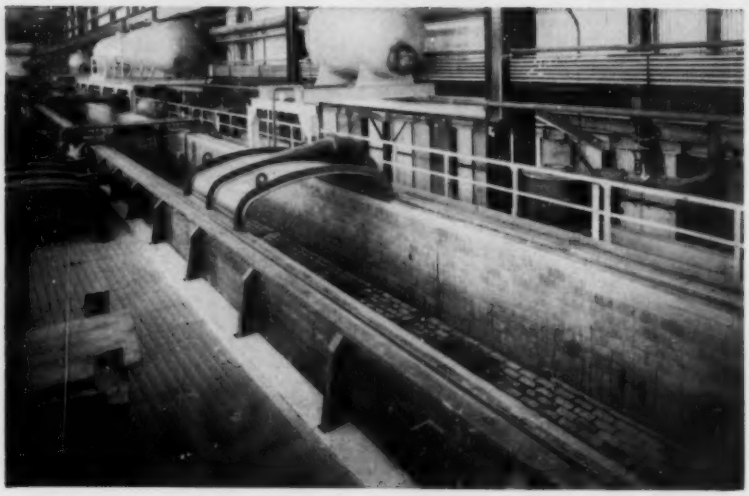
the BIG difference

BETWEEN

AVERAGE and ATLAS

PICKLE-TANK CONSTRUCTION



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Since Atlas installed the first continuous brick-lined pickler in 1933, more than 10,000,000 pounds of Atlas corrosion-proof materials of construction have been used to build all types and styles of pickling tanks throughout the world. The huge pickling tank pictured above was recently installed in a large eastern steel mill and is a typical example of Atlas design and construction in the metalworking field.

Experience has taught us a successful pickling tank requires an integrated combination of highest quality materials, tested and proven design, expert and craftsman-like construction. Only Atlas offers such a service ...a sole source of responsibility, standing behind their installation, controlling every step of the job, from the basic manufacture of the products to the final use of the material.

Why choose the average when you can benefit from the BIG difference of an Atlas pickling tank? One that will be a permanent asset ... deliver full service ... withstand the rugged abuse of modern pickling operations and not be hampered by down-time for repair of corrosion damage. Make sure you specify ATLAS for your next installation.

Write for Bulletin CC-3 giving complete information on the Atlas line.

ATLAS MINERAL PRODUCTS COMPANY
MERTZTOWN, PENNSYLVANIA

Wire Fatigue Machine for Complex Stresses

Digest of "A Wire Fatigue Machine for Investigation of the Influence of Complex Stress Histories", by H. T. Corten and G. M. Sinclair, American Society for Testing Materials, Preprint No. 67, 1956, 12 p.

THE AUTHORS describe a wire fatigue testing machine which operates on the principle of a deflected rotating strut. The equipment was designed to investigate fatigue life for complex stress histories; it differs from other wire machines in that stress amplitude may be changed rapidly from one level to another without inducing noticeable vibration in the wire specimen. The inexpensive specimens required and small scatter of data are desirable features.

The data presented were obtained during constant stress amplitude operation. First, a description of the wire fatigue machine is given. Second, a statistical study of fatigue tests in the finite region of the S-N curve is made. Third, some results are given for location of the endurance limit by the staircase method employing statistical analysis.

The use of wire specimens requires that the region of maximum stress be located away from the points where the specimen is gripped or loaded. A deflected rotating strut loaded in axial compression was described by Shelton in 1931 and by Wampler in 1939. As long as the deflected wire or strut remains in the elastic range the maximum stress can be accurately calculated. The machine is designed to test a wire 11 in. long and 0.050 in. diameter. One end of the specimen, used as the drive end, is fixed rigidly. The other end can be made to rotate in the plane of bending and in so doing governs the central deflection of the wire. The movable end fits into a miniature ball bearing and housing which is free to assume the configuration imposed by the specimen. The miniature bearing assembly is fastened to a small trolley which moves on a curved track.

Obviously, as the wire deflection is increased to raise the stress level, the distance from fixed end to movable end is slightly shortened. Theoretical design of a curved track

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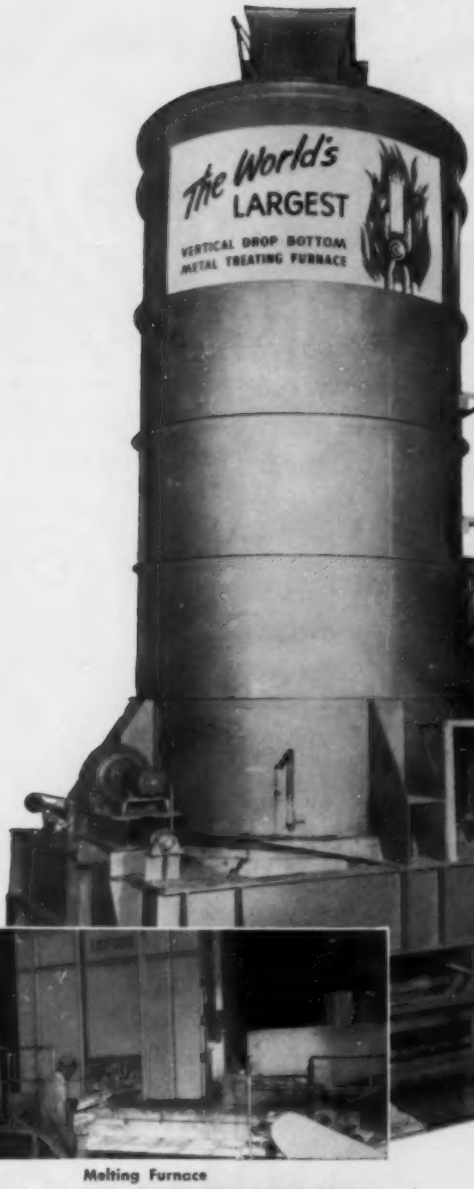

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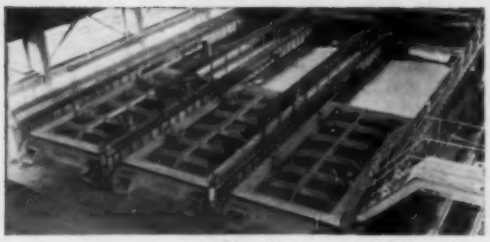

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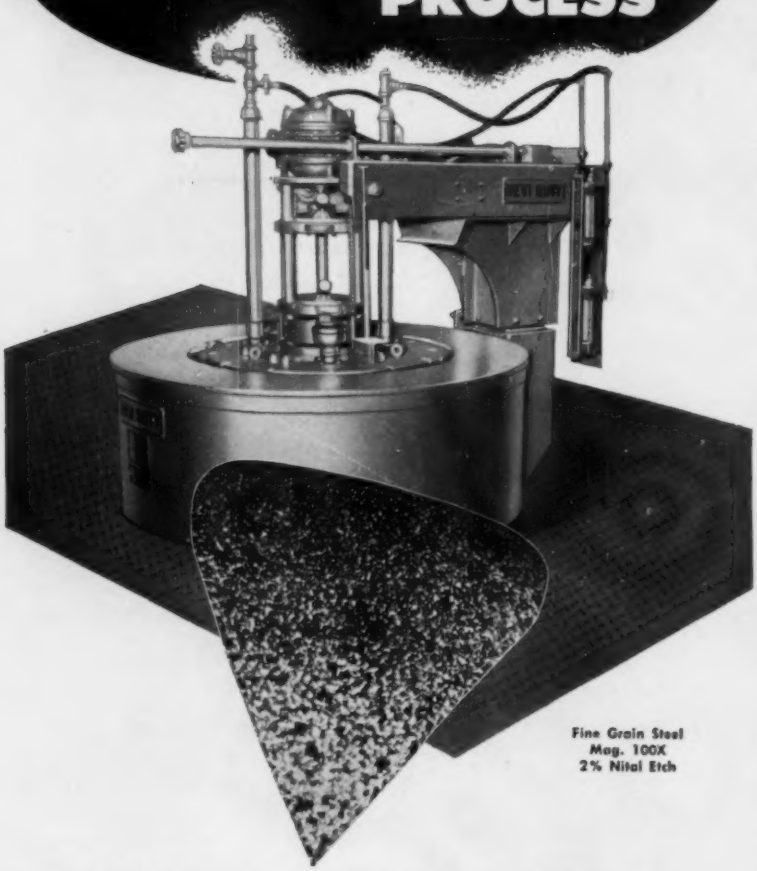

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Fatigue Testing . . .

to compensate for this shortening is possible. The authors found it more expedient to substitute a track consisting of a circular arc since the fixed known center of curvature provided a point from which the motor and chuck assembly could be accurately located. If the stress range desired is known the track can be arranged to give a minimum error in this region. By maintaining the inertia of the bearing assembly at a low value rapid changes in stress are possible by movement of the trolley on the curved track without inducing appreciable vibration.

The tensile properties of the wire, obtained by wrapping the ends around 1-in. diameter loading pins, are: yield strength at 0.2% offset 128,000 psi., ultimate strength 150,000 psi., and modulus of elasticity 30,000,000 psi.

After making a few preliminary tests to locate the S-N curve a series of finite life tests was made. When the frequency of failure is plotted on probability paper against log N, a series of straight lines is obtained representing the stress levels tested. In a previous paper one of the authors shows that plotting frequency of failure against log N rather than N corrects for the skew observed in the latter case and results in a more nearly normal frequency distribution. The small scatter of life is presumed due to the large proportion of the surface of the wire subjected to (or near) peak stress. Accordingly, the standard deviation is small and confidence limits for mean log N are narrow — a characteristic that is particularly desirable in comparison studies. The standard deviation tends to decrease with increase in stress except at the 106,000-psi. stress level. This was slightly above the proportional limit, which probably influenced the results. The distortion caused by plotting the data for very short lifetimes in terms of log N may also contribute to the increase in standard deviation at the high stress level.

In addition to the finite life data, the endurance limit was investigated by the staircase method. A test is made at a stress presumed near the endurance limit. If the specimen runs out to some preselected number

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Fatigue Testing . . .

of cycles without failure (the authors used 10^7) the test is discontinued and a second test made at some stress increment above the first. If this specimen breaks the next test is made at a lower stress. By making a number of tests in this fashion a statistical study of the endurance limit can be made. In 21 tests the authors arrived at 59,000 psi. as the mean endurance limit, with a 95% confidence limit range between 58,100 and 59,900 psi. In staircase testing the stress increment should generally be from one half to two times the standard deviation. Since in the tests reported a 2500-psi. increment was used, and since the standard deviation by statistical analysis is 480 psi., it is concluded that the data are not suited to close accuracy by the staircase method.

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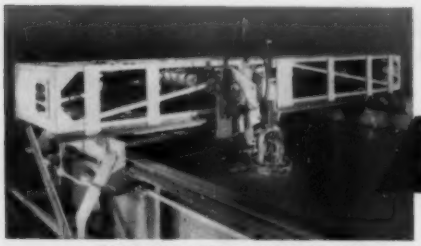

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The Titanium-CO_2 Process for Cast Iron

Digest of "The Influence of Hydrogen in the Titanium-CO_2 Process", by J. V. Dawson, B. B. Bach and L. W. L. Smith, *Journal of Research and Development*, British Cast Iron Research Assoc., Vol. 6, June 1956, p. 249-258.

THE ADDITION of titanium to cast iron is known to promote the formation of very fine graphite in a eutectic or undercooled form instead of the normal scattered flakes. This effect is found when CO_2 is bubbled through the molten iron after the titanium addition. The function of the CO_2 is not clearly explained, though it is supposed that TiO_2 might be essential for graphite refinement, and that CO_2 oxidizes the titanium to that form. High sulphur is known to interfere with refinement by making the titanium inactive as titanium sulphide. Hydrogen also interferes, a suggested reason being reduction of the TiO_2. A recent report of some British research of gas-content determination gives more definite information regarding these phenomena. The report is illustrated with excellent photographs of test-bar fractures and microstructures.

For this research seven heats of gray iron were melted in an oil-fired crucible furnace, and each was divided into four to six green sand castings 3 in. in diameter, poured after various treatments with titanium or gases. Titanium in the form of metal turnings was placed in the ladle. The melt was added to the ladle and poured back and forth between ladle and furnace until all the titanium was dissolved. The gases were bubbled into the melts generally for 4 min. The analyses of the castings varied from 2.6 to 3.5% C, 1.5 to 1.8% Si, 0.25 to 0.8% Mn, 0.017 to 0.136% S (the Mn and S were varied intentionally), 0.018 to 0.27% P, 0.12 to 0.33% Ti (when used), and from 0.4 to 6.1 ppm. hydrogen. The hydrogen content was determined by vacuum heating as soon as possible after casting small samples in graphite chill molds. Oxygen was determined by vacuum fusion on a few of the test bars.

All the 3-in. test bar castings to which titanium was added showed black sooty fractures, and graphite

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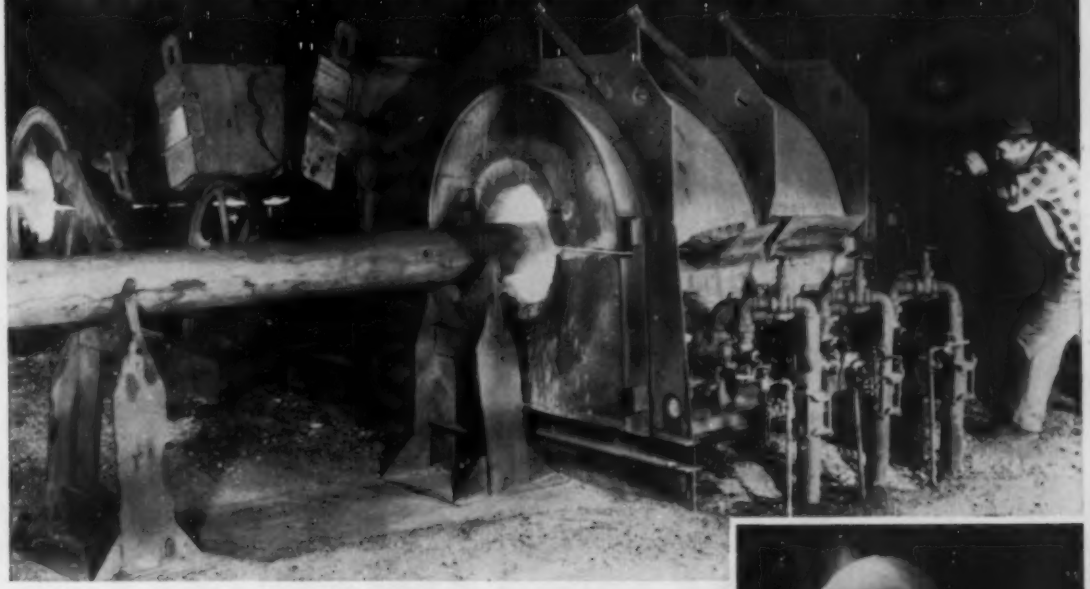

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Cast Iron . . .

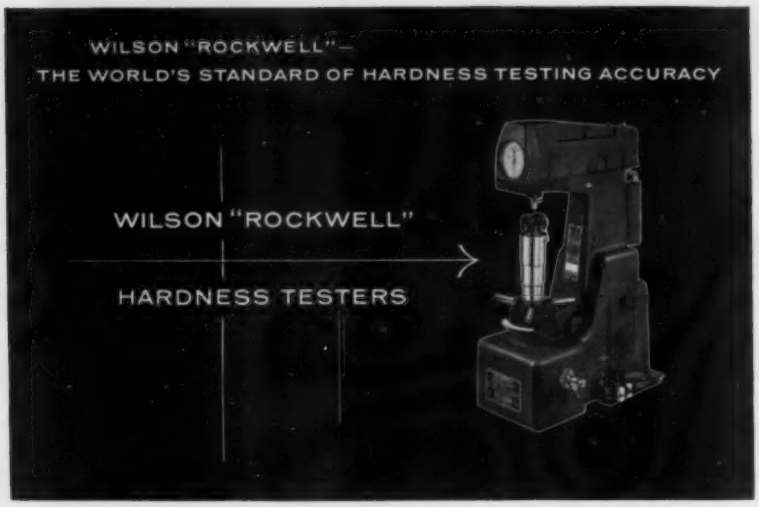
in the typical undercooled form, except when the hydrogen content was high (2.8 or more ppm.), or sulphur was present in excess of the percentage stabilized by manganese so that titanium sulphide was formed. Bubbling hydrogen (after adding titanium to an iron with sulphur not abnormally high) gave coarse flake graphite, and subsequent bubbling of CO_2 washed out the hydrogen and brought back the fine graphite characteristic of titanium, with an insignificant increase in oxygen content from 0.11 to 0.15 ppm. When argon was used instead of CO_2, the same results were obtained. In another experiment with low-sulphur titanium-bearing iron, argon changed the graphite structure from coarse to fine by reducing the hydrogen from 5.2 to 1.2 ppm. with no change in oxygen content. Thus low hydrogen, and not oxidation, was required for the consistent refinement of graphite in cast iron by titanium.

A few smaller melts were made in a vacuum at 2370° F. using a titanium-bearing iron in which the graphite had been coarsened to the common flake form by hydrogen. Melting and casting in a vacuum gave fine undercooled graphite because the hydrogen was removed, but when hydrogen was admitted to the furnace before casting, the graphite was very coarse. Another sample was repeatedly remelted in a vacuum and treated with hydrogen until the sulphur content fell to 0.002% and the titanium to 0.05%. When this was finally hydrogen treated and cast it showed undercooled graphite in spite of the hydrogen and low titanium contents. This was thought to be due to the abnormally low sulphur content, but was not clearly understood.

Casting in dry sand gave the same result as in green sand. When the furnace oil burner was shut off during CO_2 bubbling, the efficiency of hydrogen removal was improved, and castings were obtained with less than 0.7 ppm. hydrogen. Such castings of titanium-bearing iron showed slightly coarser graphite near the surface than in the interior, presumably because of absorption of hydrogen from the mold. This was not noticed when the hydrogen content was 1.2 ppm. or higher.

These authors agree with Boyles' statements in 1937 that the sulphur in gray iron is responsible for the occurrence of graphite in the usual flake form instead of the undercooled form, and that more sulphur is required for this effect when the hydrogen content is very low. The graphite-coarsening effect of sulphur may be due to a small residue not combined with manganese and remaining in solution. Titanium may reduce this soluble portion to an ineffective amount. The effect of sulphur is ascribed to a delay in the solution of graphite nuclei. The action of hydrogen in coarsening graphite operates only in the presence of sulphur, and is still unexplained. The CO_2 treatment of a titanium-bearing iron assists the graphite-refining action of titanium, by reducing hydrogen content.

G. F. Comstock



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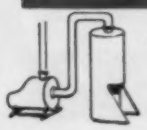
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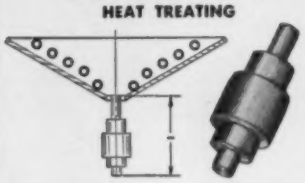

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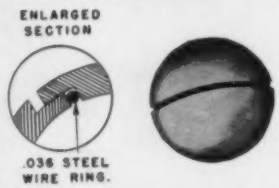

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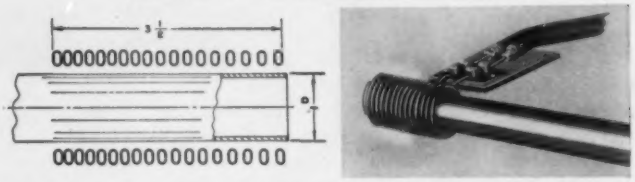

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Need for Versatile Production Tools Emphasized

Digest of "Producibility Barrier Faces Airframe Industry", by J. H. Famme, *Western Metals*, Vol. 14, November 1956, p. 59-62.

THE AUTHOR states that more highly developed production tools are needed to fabricate certain parts on recently designed aircraft and guided missiles.

Saving weight in aircraft is extremely important. Machining parts to closer tolerances results in a surprising saving of weight. By specifying the aluminum alloy skin of the plane to 0.001-in. closer tolerance, 1.44 lb. per 100 sq. ft. is saved, and with 0.01-in. less tolerance in a small plane where 1400 sq. ft. is involved the saving is 200 lb.

To attain closer tolerances more and heavier machine tools are needed. They are needed also to obtain better surface finish, which improves the resistance of the aircraft body to corrosion, fatigue, and high temperature. It is well known that the new aircraft materials are more difficult to machine. It has been predicted that a 400% increase in tools, power and labor (and therefore cost) will be needed for machining these materials when they are fully used. The tools and techniques are not being developed fast enough. It takes about four years to design, build and install a new machine tool and train an operator, just as it takes four years to develop and produce a new aircraft. Machining will probably not soon be superseded by plastic forming or other novel methods, and group research on these problems of producibility is badly needed now.

Chemical milling (removal of metal from surfaces by chemicals) has been patented by North American Aviation, Inc. as a substitute for expensive machining. With this process metal can be removed to a depth of 0.03 in. with a tolerance of 0.004 in., or with a tolerance of 0.008 in. for depths over 0.09 in. It cannot entirely replace machining on forgings. Chemical milling, however, produces less warpage, and does not require such thick webs to support machined surfaces. A cer-

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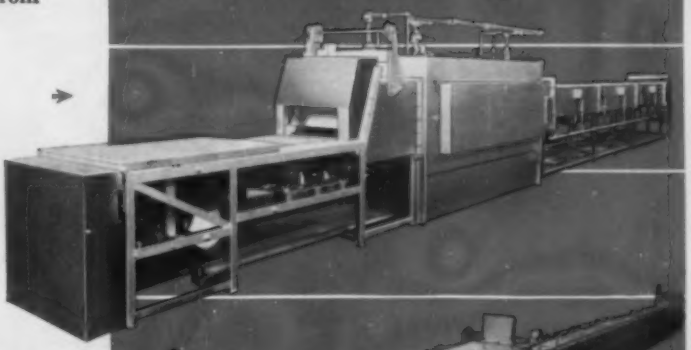

This Mesh Belt Continuous Type Furnace →

is a popular sintering furnace for small light parts in copper, bronze, brass or steel with a temperature range from 1300°F. to 2100°F. It can be used for low temperature silver brazing, bright annealing, as well as sintering of powder metals. Production ranges up to 500 pounds per hour.

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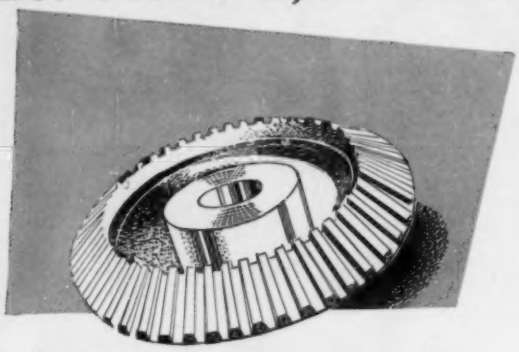

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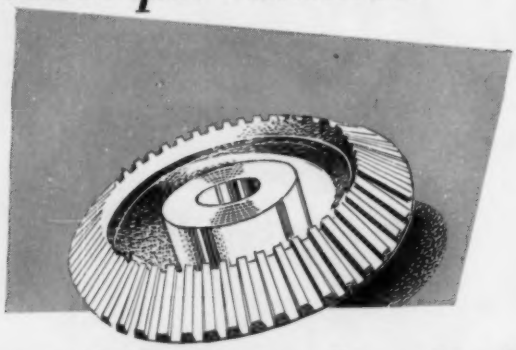

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Forging of large parts, such as wing spars in dies in heavy presses, was first developed to attain a high strength-weight ratio without too much machining of small component parts. But before the large presses were available, aircraft design had progressed so far that the weight problem again became critical, and now 70% of the metal even in these large forgings is being milled off. Aluminum alloys are less plastic than steel at the forging temperature, and more excess metal has to be left on the forging than the service stress requires.

Machining tolerances are easily held to ±0.01 in., but this is not close enough for the best economy in weight. Warping and time would be saved by a machine that could mill both sides of a flange simultaneously. Radical advances in machining and new uses for chips are greatly needed, because the aircraft industry at present produces more chips than machined parts.

The new jet transport to be ready in 1960 will have to be made with the same materials and methods now in use, because newer devices for production will not be ready in time. Machine tool builders should be preparing now for the new materials and machining methods that will be needed later.

G. F. COMSTOCK

Effect of Strain on Oxidation Rates of Ni-Cr Alloys

Digest of "Effect of Strain on the Oxidation of Nickel-Chromium Heater Alloys", by E. A. Gülbransen and K. F. Andrew, American Society for Testing Materials, Special Technical Publication No. 171, 1955, p. 35-46.

THE OXIDATION resistance of an alloy can be evaluated by measuring the change in weight after heating in an oxidizing atmosphere at a constant temperature, or after repeated cycles of alternate heating and cooling. In the latter method

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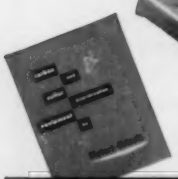

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Oxidation . . .

stresses caused by the changing temperatures are also involved. The two methods therefore give different results. The effect of stress has been demonstrated in an interesting way at the Westinghouse Research Laboratories by applying strain at an intermediate stage between two constant-temperature oxidation tests, and comparing the rate of oxidation before and after straining.

This work was done on electric heater alloys of nickel containing about 20% Cr, 0.04 to 2.30% Mn, and 0.23 to 2.09% Si, in the form of thin strips about 0.4 in. wide. Most of the specimens were oxidized at 1650° F. in a closed vessel, which was first evacuated, and then filled with pure oxygen at a pressure of 7.6 cm. Hg. Strain was applied in tension at room temperature to the extent of 1 to 4% (usually 2%) elongation. The oxidation was measured as a gain in weight per unit area, using a sensitive microbalance.

The weight gains per unit area, squared to correspond with the parabolic rate law, were plotted against time both before and after the application of strain, to compare the oxidation rates. Most alloys showed greater oxidation immediately after the test than immediately before, indicating short-term damage. The oxidation rate an hour or more after straining might, however, be either greater than before (indicating long-term damage) or less than before (indicating long-term improvement).

Comparative tests of the low-manganese alloys containing 0.23 and 2.09 Si respectively, strained 2% after being oxidized at 1650° F. to a weight gain of about 45 micrograms per sq. cm. (equivalent to about 2770 Angstroms increase in thickness) showed both short-term and long-term damage for the low-silicon alloy, and very slight short-term damage with a long-term improvement for the high-silicon alloy. This comparison agrees with that shown by the A.S.T.M. useful-life test, which involves alternate heat-

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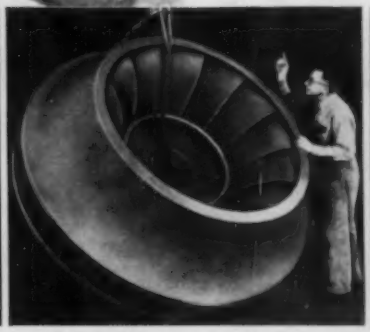

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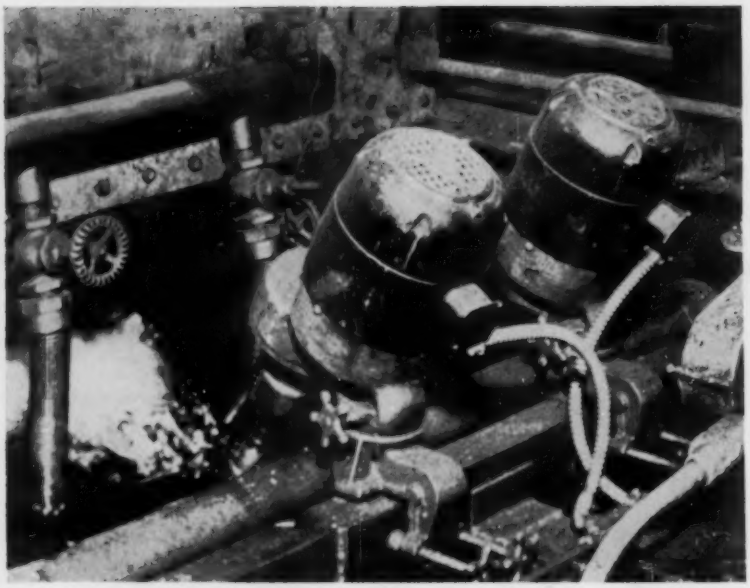

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Oxidation . . .

ing and cooling, but is contrary to a comparison based merely on the rates of oxidation. The high-silicon alloy oxidized much faster than the low-silicon before straining, but after straining its resistance to oxidation was improved instead of being impaired. This was true also of all the alloys containing over 1% Si, irrespective of manganese content, in agreement wtih the A.S.T.M. test results.

When the low-silicon alloy was oxidized to the extent of only 12 micrograms weight gain per sq.cm., corresponding to 738 A increase in thickness before straining, there was an improvement in oxidation rate after straining, instead of damage, as with specimens oxidized more before straining. In the high-silicon alloy, however, the long-term improvement by straining persisted even in a specimen oxidized to the etxent of 66.5 micrograms weight gain per sq.cm. before straining.

In similar tests of the low-silicon alloy, oxidized to about 44 micrograms weight gain per sq.cm. before straining, the short-term damage increased as the strain was raised from 1 to 4% elongation. With only 1% strain the long-term effect was an improvement, but long-term damage occurred after 2, 3, or 4% strain. With the high-silicon alloy there was a long-term improvement under the same conditions after all these amounts of strain.

Similar tests were made on the same alloys at 1740° F., using 2% strain and specimens oxidized before straining to the extent of about 44 and 66 micrograms weight gain per sq.cm. respectively for each alloy; the results confirmed those obtained at 1650° F. The high-silicon alloy, with A.S.T.M. useful life nearly three times longer than that of the low-silicon alloy, oxidized much faster both before and after straining, but its rate of oxidation was decreased by the strain while that of the low-silicon alloy was increased. The cumulative damage from stress explains why low-silicon alloys give inferior results in oxidation tests involving alternate heating and cooling, even though their oxidation rates at constant temperature are lower than with higher silicon.

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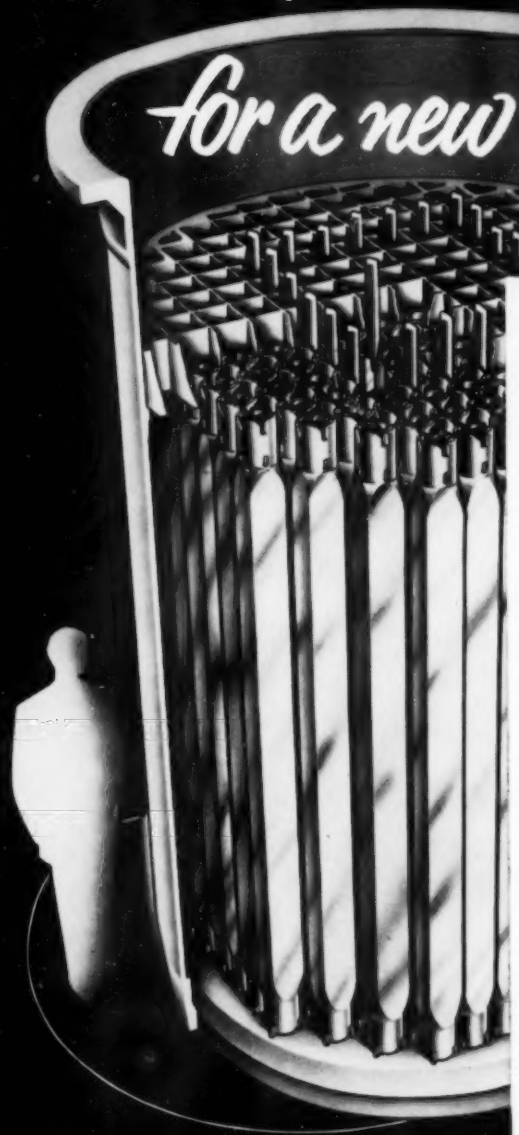

This sectional view of the Shippingport pressurized water reactor shows the nuclear fuel elements developed at the Westinghouse Bettis Plant where metallurgists are working on challenging problems to develop a variety of reactor alloys.

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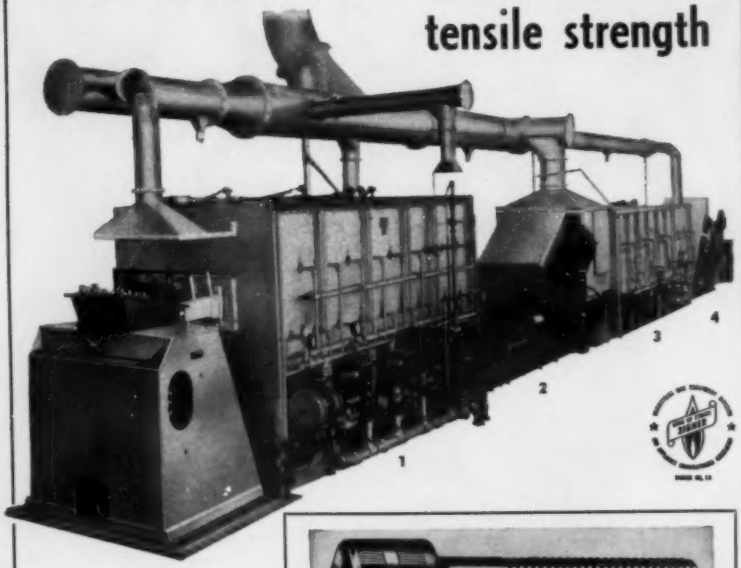

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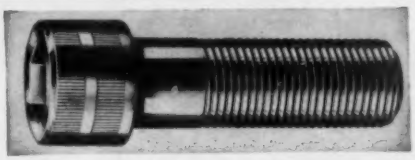

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High-Temperature Corrosion of Stainless Steel

Digest of "The Effects of Contamination by Vanadium and Sodium Compounds on the Air-Corrosion of Stainless Steels", by G. W. Cunningham and Anton de S. Brasunas, *Corrosion*, Vol. 12, August 1956, p. 389t-405t.

THIS PAPER deals with the unusually severe high-temperature corrosion of heat resistant alloys occuring under conditions where certain low-melting contaminants are present at the metal surface. This type of corrosive attack, frequently observed in combustion gas environments, apparently results from the destruction by the contaminants of the corrosion resistant layer that normally forms on heat resistant alloys. The altered surface layer, no longer an effective barrier to diffusion, permits corrosion to proceed unimpeded, frequently at catastrophic rates. The objective of the present paper was to achieve a better understanding of the mechanism of this type of corrosion giving particular attention to the behavior of contaminants rich in sodium sulphate and vanadium pentoxide. Such compounds occurring as combustion products from certain fuel oils had been previously described as particularly detrimental in this respect.

Experiments were carried out in which specimens of several heat resistant alloys (including the austenitic, martensitic, and ferritic stainless steels, and Duriron) were heated in contact with the contaminants in question under varying conditions of composition, time and temperature. From the observed results, several noteworthy conclusions were drawn. For example, an apparent correlation was found between the severity of corrosion and the dissolved oxygen content of the molten contaminants. Furthermore, the severity of attack was aggravated upon repeated, rather than continuous, applications of the contaminant mixture made during prolonged holding of the specimens at elevated temperature.

With reference to specific characteristics and conditions accompanying accelerated corrosion the authors

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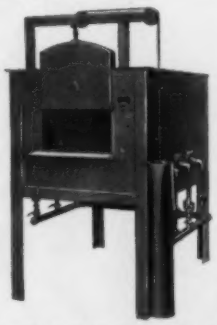

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Corrosion . . .

offered a number of conclusions, including the following:

1. A molten oxide film is necessary for the promotion of accelerated corrosion. At temperatures below the melting point of the contaminant, the normal corrosion rate is encountered.

2. An incubation time may be encountered which may be the time required for the contaminant to react with the thin oxide film normally present.

3. In the vanadium-rich mixtures, the rate-controlling step at constant temperature appears to be the rate at which oxygen passes through the molten film to the metal surface.

4. The unusually high corrosion encountered when 80% V_2O_5 + 20% Na_2SO_4 is present as contaminant on the surface of a heat resistant alloy at temperatures above 1500° F. is caused by the following reaction between metal and the oxygen dissolved in the molten contaminant: Metal + High O_2 Contaminant → Metal Oxide + Low O_2 Contaminant. Thus the molten layer appears to act primarily as an oxygen carrier and as a destroyer of protective films.

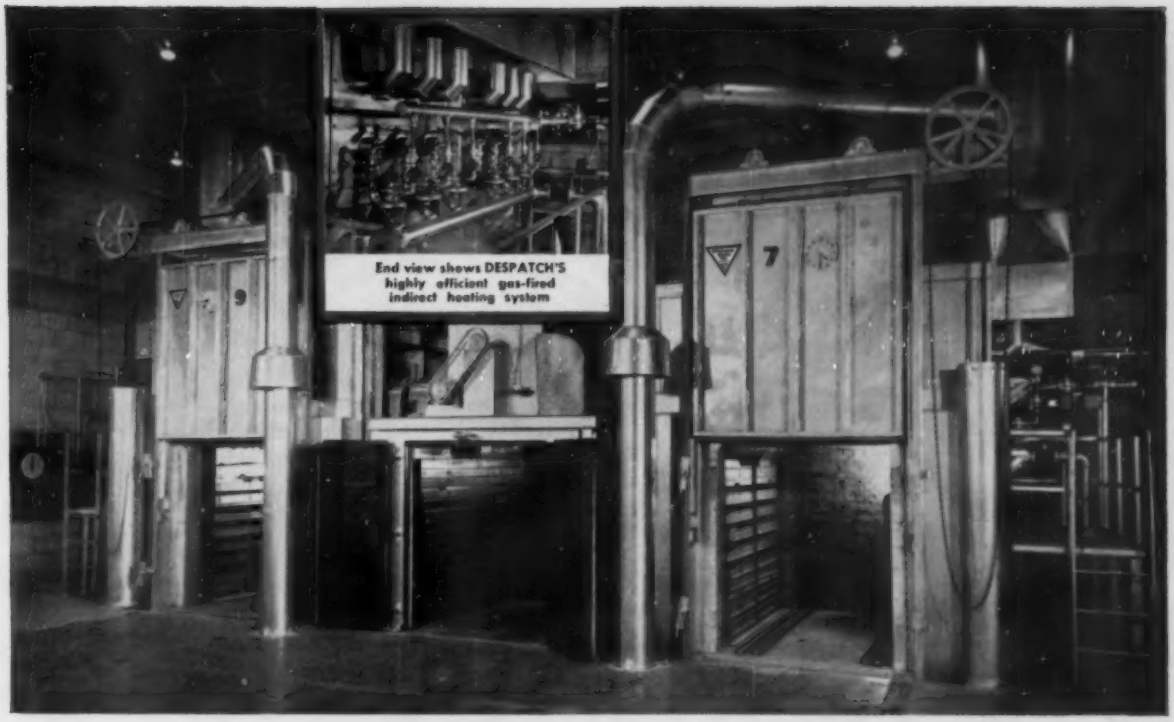
W. W. AUSTIN

Effect of Moisture on Electrode Coatings

Digest of "The Effects of Moisture in the Coatings of Metal Arc Welding Electrodes", by P. D. Blake, *Welder* (British), Vol. 25, April-June 1956, p. 35-40.

MAJOR SOURCES of hydrogen in the welding arc atmosphere are: (*a*) moisture in the electrode coating, (*b*) water of crystallization, (*c*) structural hydroxyl (OH) groups in the minerals comprising the coating, and (*d*) atmospheric moisture.

Hydrogen is absorbed in the molten metal according to Sievert's square root law, a particular case of Henry's law for gas-metal systems. This law states that the amount of hydrogen absorbed by the metal is proportional to the square root of the partial pressure of hydrogen in the arc atmosphere above the weld pool. Such partial pressure may be influenced by reac-



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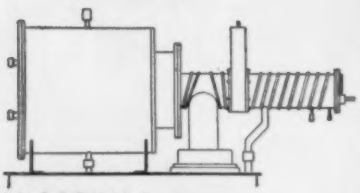

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Welding Electrodes . . .

tions between the slag, metal and arc atmosphere gases.

Potential hydrogen present in an electrode coating is of some importance from the viewpoint of possible embrittlement of the weld metal. This hydrogen varies considerably according to the temperature and relative humidity of the atmosphere in which the electrodes have been stored and the period of storage, as well as according to whether or not the electrodes are dried by baking upon removal from storage.

At the same time, for certain electrodes, some moisture in the arc zone is a necessary feature for best arc operating characteristics, but excessive quantities of hydrogen in the weld deposit are undoubtedly harmful and can lead to cracking, porosity and "fisheyes".

The potential hydrogen content of electrode coatings can be determined by passing purified dry oxygen over chips of the coating held at 2370° F. for 1 hr., so that the entire moisture content is released by the heat and carried by the stream of oxygen into preweighed anhydrite U-tubes. The increase in weight of these U-tubes is equal to the weight of moisture present in a given weight of coating, and from this figure the weight percentage of moisture and potenial hydrogen content can be calculated.

Maximum total moisture content in the coating acceptable for mild steel low-hydrogen type electrodes is less than 0.8%, and less than 0.4% for certain high-strength Ni-Mo-V low-alloy ferritic type electrodes.

The term "total moisture content", measured at 2200 to 2370° F., is intended to include retained moisture, absorbed moisture, water of crystallization and structural (hydroxyl) water. However, with a poorly designed electrode it is still possible for hard-zone cracking to occur due to a preponderance of other factors at low-potential hydrogen levels.

The "high-potential hydrogen" group of electrodes may include all of the four sources of moisture in their coatings, as previously men-

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WRITE FOR ILLUSTRATED CATALOG M 55

QUENCHING: a bucket full of money goes in, but what comes out?

Consider the money value that goes in and out of quenching baths. The price of the metal, plus the price of machining, plus the price of heat treating up to the quench can be a big item. Every time you quench a part, you're betting its value against the quality and dependability of the quench.

That's why it's so important to be sure of the quality of the quenching oil you use. The easy way to do it—standardize on Houghto-Quench. You'll get a built-in safety factor, get the exact results you want, or better. You'll get quenching oil that is compounded to meet your specific requirements.

Best of all, you'll get a highly economical, clean quenching bath that will last almost indefinitely. Houghto-Quench doesn't break down. It doesn't form sludge. In low cost per ton of steel quenched, it consistently beats other oils in test. May we prove it?

QUENCHING OILS

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Ready to give you on-the-job service . . .

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looks like a crayon... marks like a crayon... tells temperatures like a precision instrument!

Sixty-three different compositions enable you to determine and control working temperatures from 113° to 2000° F. TEMPILSTIK° marks on workpiece "say when" by melting at stated temperatures—plus or minus 1%.

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FREE Tempil "Basic Guide to Ferrous Metallurgy"—a 16¼" x 21" plastic-laminated wall chart in color.

Send for sample pellets, stating temperatures of interest to you.

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Welding Electrodes . . .

tioned, and, where cellulose or similar materials are present, drying of the electrode is undesirable because of the breakdown of the cellulose with consequent deterioration in the running properties of the electrode.

Cellulose coatings require a reasonable moisture content, and, in general, moisture in these coatings does not appear to increase the partial pressure of hydrogen over the weld pool. Moreover, the moisture may control the decomposition of the organic part of the coating. Usually these electrodes operate most efficiently at an optimum moisture level, which may also be connected with the need for a certain amount of effective oxygen in the arc atmosphere.

The "intermediate-potential hydrogen" group of electrodes generally contain less organic structural water because they have either smaller amounts of cellulosic material or none at all. The principal function of such coating is to provide a CO/CO_2 gas shield for the arc, to insure arc stability and prevent oxidation of the weld pool. In this class of electrodes, materials such as carbonates provide some of the gas shield.

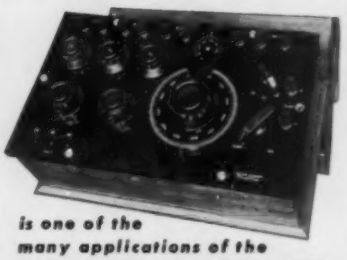
The "low-potential hydogen" electrodes may inherently contain retained moisture in the coating. Many are produced with a view to being amenable to high-temperature baking treatments during manufacture, while still retaining or possibly improving their running properties. The gas shield is provided by carbonates in the coating whose nature is modified by the incorporation of fluorides as fluxing materials. Fluoride compounds may play an important part in the gas-slag-metal reactions.

It may be concluded that while for cellulosic and rutile electrode coatings moisture is essential to maintain optimum arc operating conditions and for the completion of certain gas-metal-slag reactions, it is still desirable to have a low hydrogen-to-water ratio over the weld pool, since hydrogen in the weld deposit is detrimental.

Basic lime-fluoride electrodes are designed to operate satisfactorily, although using a short arc, without the presence of moisture in the arc

Precise

TEMPERATURE MEASUREMENT



is one of the many applications of the

TYPE B HIGH PRECISION POTENTIOMETER

...a general purpose potentiometer with a number of notable refinements, suiting it particularly to thermocouple work. Distinctive features include:

- Three ranges—0 to 16 millivolts, 0 to 160 millivolts and 0 to 1.6 volts.
- Three reading dials—effective scale length of approximately 175 feet for each range.
- Subpanel switch and slidewire construction for protection of contacts from dust and corrosive fumes.
- Special provisions to minimize parasitic thermal emf's—including automatic compensation of slidewire thermals and gold contacts in galvanometer key.
- Exceptional convenience in reading and adjustment.
- Solid and substantial construction for many years of trouble-free service.

This standard laboratory potentiometer is also well suited for meter calibration, for checking portable potentiometers, and for other critical measurements of D.C. potentials requiring exceptionally high accuracy.

Described in Bulletin 270

SPOTLIGHT GALVANOMETER FOR SHOP AND LABORATORY WORK

- Sturdy, short period
- Sensitive (up to 1.5 μV per mm.)
- Multiple-reflection optical system
- 100-Millimeter scale
- For null or deflection measurements

Described in Bulletin 320

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Welding Electrodes . . .

zone, and with these electrodes the moisture content is detrimental with regard to both weld quality and electrode utility.

Some basic electrodes used for crack-insensitive weldments may have total coating moisture contents of up to 2%. These would not be so suitable for the high-carbon steels, or for vitreous enameling steels, high-sulphur steels, silicon steels or some low-alloy steels. The ultra-low hydrogen electrodes are being increasingly used for welding the latter materials.

ARTHUR H. ALLEN

High-Temperature Strength of Cr-V and Cr-W-V Steels for Bolts

Digest of "High-Temperature Strength and Relaxation Strength of Chromium-Vanadium and Chromium-Tungsten-Vanadium Constructional Steels", by L. Liberman and A. V. Boeva. *Metallovedenie i Obrabotka Metallov*, No. 4, April 1956, p. 2-10.

THE PRINCIPAL AIM of this investigation was to develop a steel that could be substituted for the present molybdenum-containing steels in bolts operating at temperatures as high as 815° F. in boilers and turbines. Nine special steels were prepared for this purpose. In addition to about 1.6% Cr the steels contained 0 to 2% W, 0 to 1% V, and 0.23 to 0.40% C. The mechanical properties were determined at 70 and 930° F., and all of the steels fell in the same range after a quenching and tempering treatment that produced a microstructure of sorbite or sorbite plus ferrite.

A number of important properties were studied as a function of alloy content. Thus, it was found that the susceptibility to temper brittleness increased slightly with increase in carbon content but decreased as the tungsten content increased. Vanadium had a peculiar effect on temper brittleness in that 0.5% V exerted a strongly deleterious action, while 0.25 or 1.0% V produced only slight temper brittleness. The damaging effect on mechanical proper-

...a multiple-zone, general-purpose, controlled atmosphere, heat treating furnace

This T-12-150A multiple-zone furnace with integral quench illustrates an optional arrangement with preheat.

...the Ipsen Automatic Straight-Through "A" model

for carburizing and carbonitriding

This furnace is suitable for both carburizing and carbonitriding. Why? Because its two zones are *independently controlled.*

Here's an example of the extreme versatility of the Ipsen "A" model: Work can be uniformly heated and soaked in the first zone. In instances where greater case depths are required, the second zone can be used for additional soaking, then if desired, *uniform* cooling by forced convection can be used to lower the temperature of the work load before quenching. Thus, during carburizing and direct quench cycles, retained austenite is eliminated, and distortion reduced. During a carbonitriding cycle, the ammonia flow can be shut off at the end of the cycle to eliminate surface "skin."

What does "automatic, straight-through" mean? Simply this... First, a power loader charges the work load into the first zone, and transfers a preceding load into the second zone. When the charge is ready for the quench, the Ipsen patented cold chain transfer takes over. Cold lugs, on two parallel alloy chains, contact work basket, moving it to the next position. *Hot portion* of chain is always *beyond* driving sprocket... thus only the cold part of the chain moves the work.

In-line work movement is automatic throughout the furnace!

Heating is 100% forced convection. Roof fan circulates atmosphere down past vertical ceramic radiant tubes, to bottom of work chamber, then up through all parts of charge. Uniform temperatures are maintained... distortion due to uneven heating is eliminated. Gas-fired furnaces use Ipsen Flame-Busters which are a series of ceramic links, suspended chain-like inside each ceramic radiant tube. They break up the flame path, disperse heat over a greater length of the tube, eliminate hot spots, and increase heating capacity 50%.

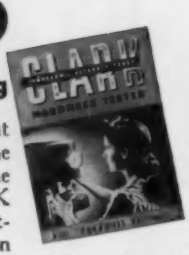
The "A" model is available in three standard sizes, with productive capacities ranging from 900 to 2000 lbs. per hour. Single zone furnaces of similar design are available. For additional information ask for Bulletin T-19A.

AUTOMATIC Ipsen HEAT TREATING UNITS

IPSEN INDUSTRIES, INC. • 723 SOUTH MAIN STREET • ROCKFORD, ILLINOIS

GET THE FACTS

About Hardness Testing



Everything you need to know about hardness testing is told in this handsome book, prepared by the makers of the internationally respected CLARK Hardness Testers for "Rockwell Testing." Simple, easy-to-read text (in English) and numerous illustrations show the equipment and procedure for fast, accurate hardness testing of ferrous and non-ferrous materials. If you would like a copy, *free of charge*, just attach this ad to your letterhead or write "Send book." A copy will be mailed to you promptly.

P.S. If you are interested in descriptions and prices for CLARK Hardness Testers (Standard and Superficial) of *guaranteed accuracy*, say the word and we'll gladly supply them.

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Steel for Bolts . . .

ties of heating for 3000 hr. at 930° F. was also studied. Only steels containing 0.5 or 1.0% V experienced a marked loss in impact strength as a result of this treatment. Their impact strengths were reduced to as little as 10% of the original values. Other steels retained as much as 100%.

Creep, rupture, and relaxation strengths were determined for all of the steels. In all tests steel 25 Kh 2 V 1 F (0.23% C, 0.40% Si, 0.45% Mn, 1.40% Cr, 1.10% W, 0.27% V, 0.034% S, 0.025% P) was the best. At 930° F. and 14,000 psi. its creep rate was 1.35×10^{-5}% per hr. At 930° F. its rupture strengths for 1,000, 10,000 and 100,000 hr. were 51,000, 36,000, and 27,000 psi., respectively. These values were almost equal to those of the widely used molybdenum-containing alloy 25 Kh 2 MFA (0.25% C, 1.7% Cr, 0.2% Mo, 0.2% V). The relaxation strength of the new alloy was also about the same as that of the molybdenum steel. A. G. GUY

Pangborn Hydro-Finish cut cleaning time 50% in this plant

Paid for itself in only six months

Pangborn Hydro-Finish really paid off for this leading glass manufacturer. Cleaning quality increased moldlife 10% to 15% and total cleaning and polishing time was cut in half! The resultant savings paid for the machine in six months and represented a substantial weekly sum thereafter.

USE PANGBORN HYDRO-FINISH FOR:
Deburring • Surface finishing • Finishing threaded sections • Improving cutting tool life • Maintaining dies and molds • Removing grinding lines • Removing heat treat scale • Preparing surfaces

Today, through new design and use of air jet sluriators, Pangborn Hydro-Finish costs less originally, costs less to maintain and gives you easier handling and added efficiency. Write for Bulletin 1403 to PANGBORN CORP., 1800 Pangborn Blvd., Hagerstown, Md.

Pangborn
BLAST CLEANS CHEAPER

These Oakite shortcuts speed your metal cleaning

1 **Cleaning and rustproofing—*in one washing operation***

Oakite Composition No. 98 (used cold or hot in one-stage or two-stage washing machines) removes cutting oils and chips—while it leaves a thin film that protects steel against rusting between operations or during temporary storage.

Excellent for cleaning before inspection: the metal is cool for immediate handling and the film (too thin to affect measurements) prevents finger prints from corroding highly finished surfaces.

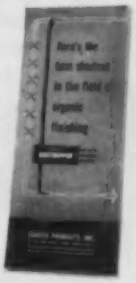
One auto manufacturer uses No. 98 in seven plants for cleaning and rustproofing brake cylinders, camshafts, connecting rods, crankshafts, cylinder heads, flywheels, push rods, tappets, wrist pins, etc.

2 **Stripping pigmented paints—*with no need for pickling before repainting***

Oakite Rustripper saves money in paint shops by doing a complete stripping job in one operation. It eliminates extra pickling and neutralizing to remove the metallic pigments, phosphate coatings and rust that prevent successful repainting.

A television manufacturer says "We formerly took 25 minutes to strip rejected cabinets, then had to pickle to remove tarnished phosphate coatings. Today 10 minutes in Rustripper strips the same cabinet so bright and clean you can't tell it from new. Eliminates pickle, neutralize and rinses."

An auto parts maker uses Rustripper for continuous conveyor line stripping. "Cycle of 1 minute and 50 seconds works like a charm stripping paint and incidental rust from rejects and hooks."



3 **Cleaning, derusting and descaling—*in one alkaline tank***

Oakite Rustripper saves money in plating shops by removing rust or heat scale at the same time it removes oil and other soils. Alkaline pickling with Rustripper avoids hydrogen embrittlement, etching of machined surfaces and other disadvantages of acid pickling. Rustripper is also used for precleaning or electrocleaning in plating lines.

An aircraft manufacturer who formerly sand blasted to remove heat scale says "Now the scale is removed in 30 minutes in a boiling soak in Rustripper."

A job plater who adds Rustripper to his reverse-current cleaner in an automatic plating machine, says "We used to clean 45 seconds. Now 20 seconds cleans sparkling bright . . . saves precious time . . ."

FREE Write for booklets

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Send me the FREE booklets indicated below:

1. "For Power Washers—Oakite Composition No. 98"
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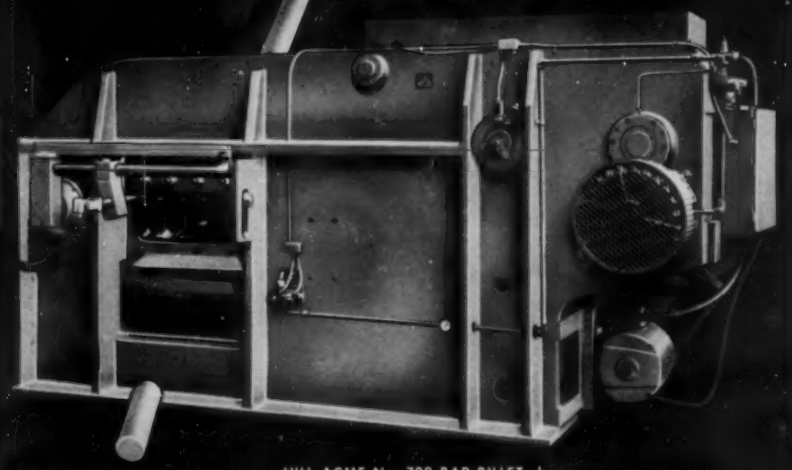

HILL ACME No. 700 BAR-BILLET shear
(Ask for Bulletin B-B)

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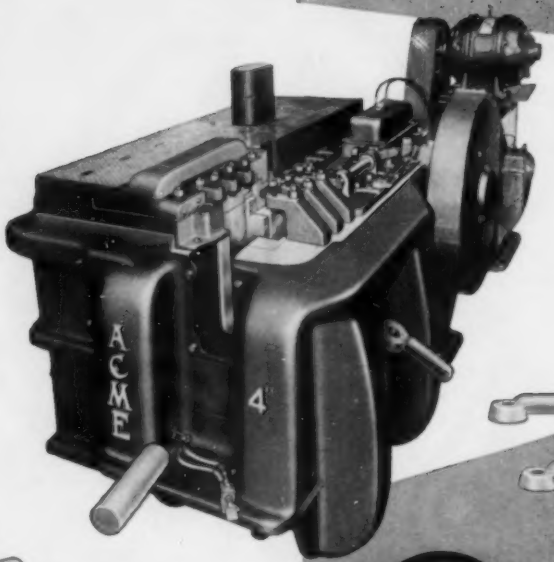
The new, improved ACME XN Forging Machine with its massive, sturdy construction is built to withstand the destructive influences present in all forging machine operations. ACME XN Forging Machines will keep going for long uninterrupted periods, producing accurate, clean forgings at a rate never thought possible a few years ago. A bulletin describing details plus a series of 18 technical articles on modern forging practice will be sent upon request.



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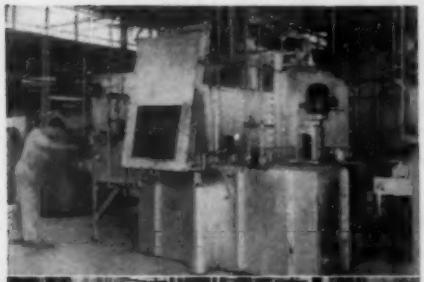
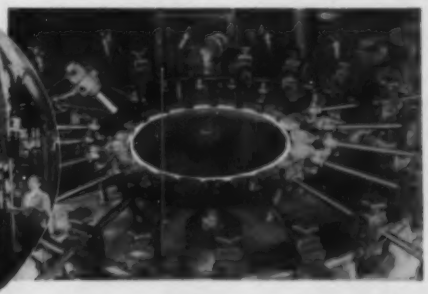
WHEN IT COMES TO HEAT TREATING—
"Do-It-Yourself" can sometimes be costly

Buying equipment and supplies to perform heat treating operations within your own plant is only one step in many that must be considered when contemplating the installation or expansion of a heat treating department.





Here are some of the factors that should be included when figuring the cost of operating your own heat treating department—of "doing-it-yourself" when it comes to heat treating:

- **Technical skill:** Trained operators whose skill is the result of years of experience are essential
- **Maintenance:** Rapid deterioration of equipment occurs unless there is constant repair, maintenance, and skillful handling of the equipment
- **Quality control:** Testing equipment and skilled operators are necessary to maintain uniformity and quality control of all heat treating operations
- **Sufficient equipment and supplies:** A great variety of equipment is needed to meet the requirements of annealing, brazing, hardening, carburizing, stress relieving, nitriding, and all other heat treating processes; and an endless variety of materials and supplies must be kept on hand.

These problems and many more have been solved by commercial heat treaters. They have the answers because heat treating is their business.

Every MTI commercial heat treater listed here is a specialist with complete service facilities under one roof. Each one has the facilities, equipment, skill and experience which will enable him to meet your most exacting heat treating requirements.

***Consult any of these* HEAT TREATING SPECIALISTS**

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Bennett Heat Treating Co., Inc.
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Hollywood Heat Treating Co.
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L-R Heat Treating Company
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Metlab Company
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South Boston 27, Massachusetts
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St. Louis 10, Missouri
Pittsburgh Commercial Heat Treating Co.
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The Queen City Steel Treating Co.
Cincinnati 25, Ohio
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Lansdale, Pennsylvania
Stanley P. Rockwell Company
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C. U. Scott & Sons, Inc.
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Winton Heat Treating Company
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This advertisement sponsored by these Companies which are members of the Metal Treating Institute.

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Entries Will Be Expected From All Over the World– –Display Your Best Work

RULES FOR ENTRANTS

Exhibitors do not need to be members of the American Society for Metals.

Work which has appeared in previous metallographic exhibits held by the American Society for Metals is unacceptable.

Photographic prints should be mounted on stiff cardboard; maximum dimensions 14 by 18 in. (35 by 45 cm.). Heavy, solid frames are unacceptable.

Entries should carry a label on the *face* of the mount giving:

Classification of entry.

Material, etchant, magnification.

Any special information as desired.

The name, company affiliation and postal address of the exhibitor should be placed on the back of the mount.

Entrants living outside the U. S. A. should send their micros by first-class letter mail endorsed "Photo for Exhibition—May be Opened for Customs Inspection".

Exhibits must be delivered before Oct. 15, 1957, either by prepaid express, registered parcel post or first-class letter mail, addressed:

Metallographic Exhibit
American Society for Metals
7301 Euclid Ave.
Cleveland 3, Ohio, U.S.A.

CLASSIFICATION OF MICROS

(*Optical and Electron*)

Class 1. Irons and steels.
Class 2. Stainless steels and heat resisting alloys.
Class 3. Aluminum, magnesium, beryllium, titanium and their alloys.
Class 4. Copper, nickel, zinc, lead and their alloys.
Class 5. Uranium, plutonium, thorium, zirconium and reactor fuel and control elements.
Class 6. Metals and alloys not otherwise classified.
Class 7. Series showing transitions or changes during processing.
Class 8. Welds and other joining methods.
Class 9. Surface coatings and surface phenomena.
Class 10. Results by unconventional techniques (other than electron micrographs).
Class 11. Slags, inclusions, refractories, cermets and aggregates.
Class 12. Color prints in any of the above classes. (No transparencies accepted.)

AWARDS AND OTHER INFORMATION

A committee of judges will be appointed by the Metal Congress management which will award a First Prize (a medal and blue ribbon) to the best in each classification. Honorable Mentions will also be awarded (with appropriate medals) to other photographs which, in the opinion of the judges, closely approach the winner in excellence. A Grand Prize, in the form of an engrossed certificate and a money award of $100, will also be awarded the exhibitor whose work is judged best in the show, and his exhibit shall become the property of the American Society for Metals for preservation and display in the Society's national headquarters in Cleveland.

All photographs may be retained by the Society for one year and placed in a traveling exhibit to the various Chapters. They will be returned to the owners in May 1958 if so desired.

The Twelfth Metallographic Exhibit

Chicago, Illinois, November 2 to 8, 1957

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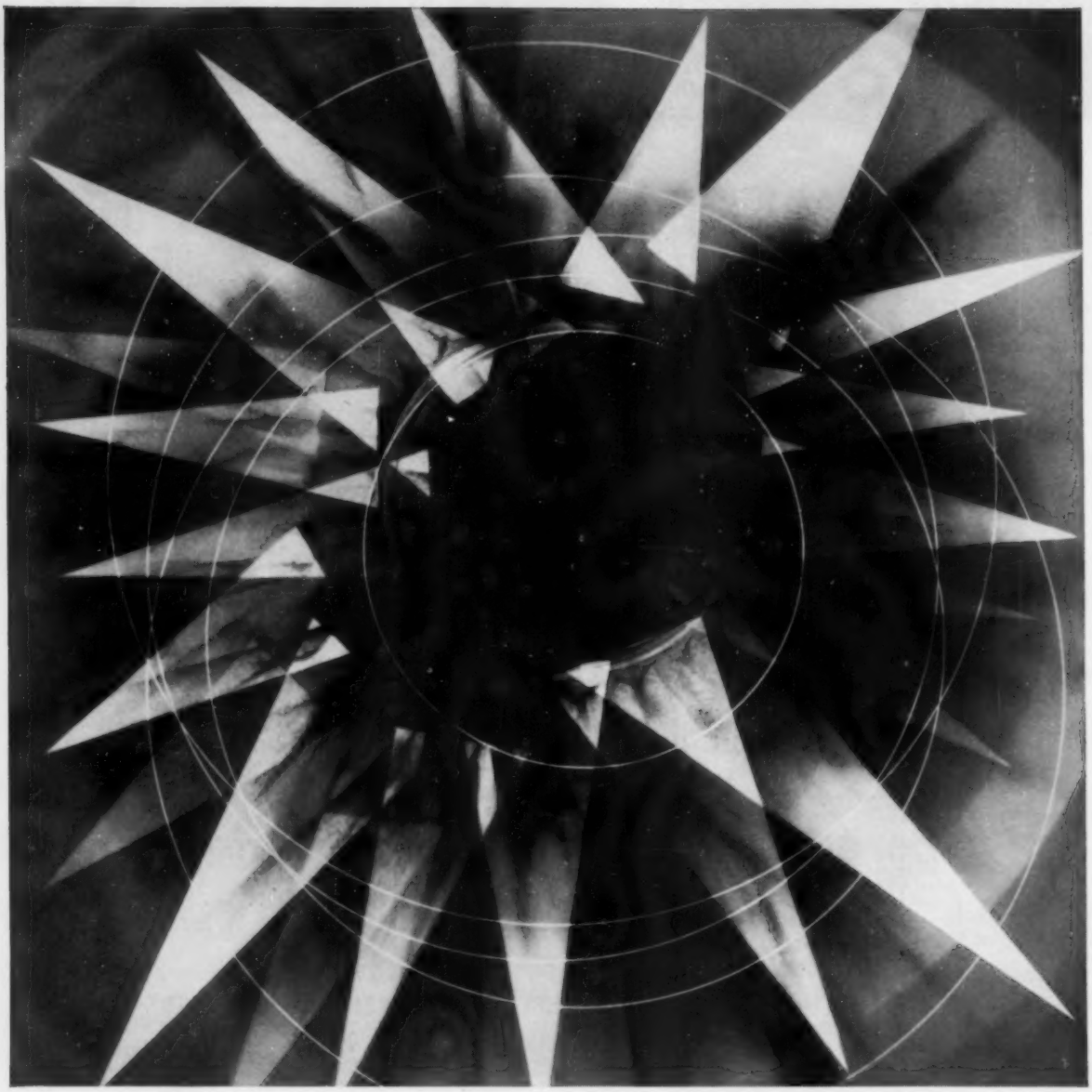
GA ALLOYS THE QUALITY NAMES IN ALLOY FOR HEAT CORROSION ABRASION X-ite



breaking the barriers
with Utica Vacuum Metals

Now that supersonic flight has become routine, today's challenge lies in developing *metals* and *means* of cracking the thermal barrier.

The metals problem has already been partially solved by superalloys produced through Vacuum Melting. This process, as developed by Utica, has yielded such super refractory alloys as Udimet 500—a clean, pure alloy combining unsurpassed stress-rupture life with superior high tensile strength in the 1200° F to 1800° F range. *At 1600° F, Udimet 500 has a tensile strength of over 100,000 PSI.*

In addition to the development of new and superalloys, Utica specializes in upgrading the quality of existing alloys.

VACUUM MELTING
provides these properties

- High temperature corrosion resistance
- Increased ductility
- Extreme cleanliness
- Precise chemical control
- Longer stress-rupture life
- Increased tensile strength
- Better fatigue resistance
- Greater yield strength
- Greater impact resistance
- Greater creep properties

UTICA METALS DIVISION OF KELSEY-HAYES

UTICA DROP FORGE & TOOL DIVISION — KELSEY-HAYES CO., UTICA 4, NEW YORK

HOW TO CONTROL ATMOSPHERES...

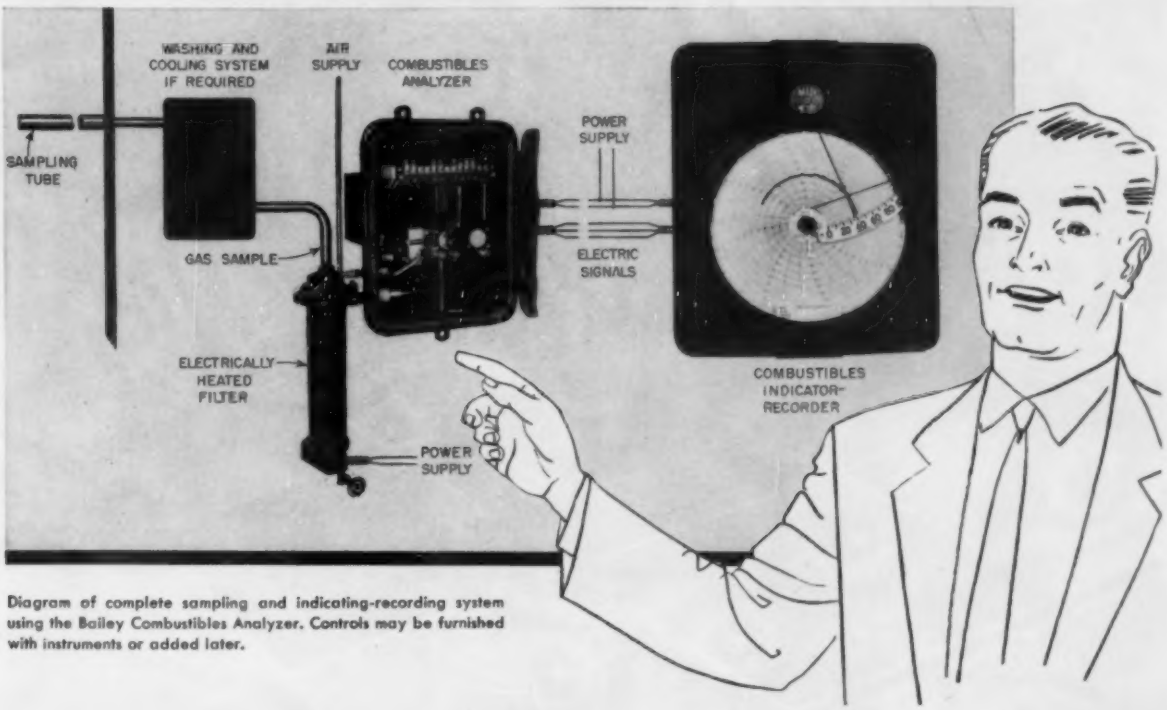


Diagram of complete sampling and indicating-recording system using the Bailey Combustibles Analyzer. Controls may be furnished with instruments or added later.

BAILEY COMBUSTIBLES ANALYZER

improves steel quality, saves gas

Whether you are doing bright annealing, hardening, normalizing or carburizing, keeping a constant watch on your atmospheres with a Bailey Combustibles Analyzer will help you do a better job at lower cost. This instrument provides a continuous measurement of the per cent combustible in the protective atmosphere gasses. It operates a remote electronic receiver for indicating, recording and controlling.

The Bailey Combustibles Analyzer monitors the quality of atmosphere gas. When the quality changes, as shown by changes in the per cent combustibles, the Analyzer operates a pneumatic controller which automatically controls the fuel rate. By maintaining the proper gas-air mixture, the uniformity of the atmosphere—and of the final steel product—is protected.

An important use for the Bailey Analyzer is in furnace purging—necessary to prevent explosion during startup. The instrument tells the operator when the combustibles have been reduced to a point where it is safe to start up the furnace. Without a Bailey Analyzer, purging is usually done strictly on a time basis, a procedure that is wasteful and unsafe.

Put the Bailey Combustibles Analyzer to work as a watchdog and control on your atmosphere generators and heat treating furnaces. It is the one way you can be sure you are maintaining the atmospheres specified by metallurgists for your processes.

Your Bailey Engineer will show you how you can use this instrument to improve steel quality and save gas. Or, write to our Iron & Steel Division for Product Specification E65-3 with complete details. 58-1

BAILEY METER COMPANY

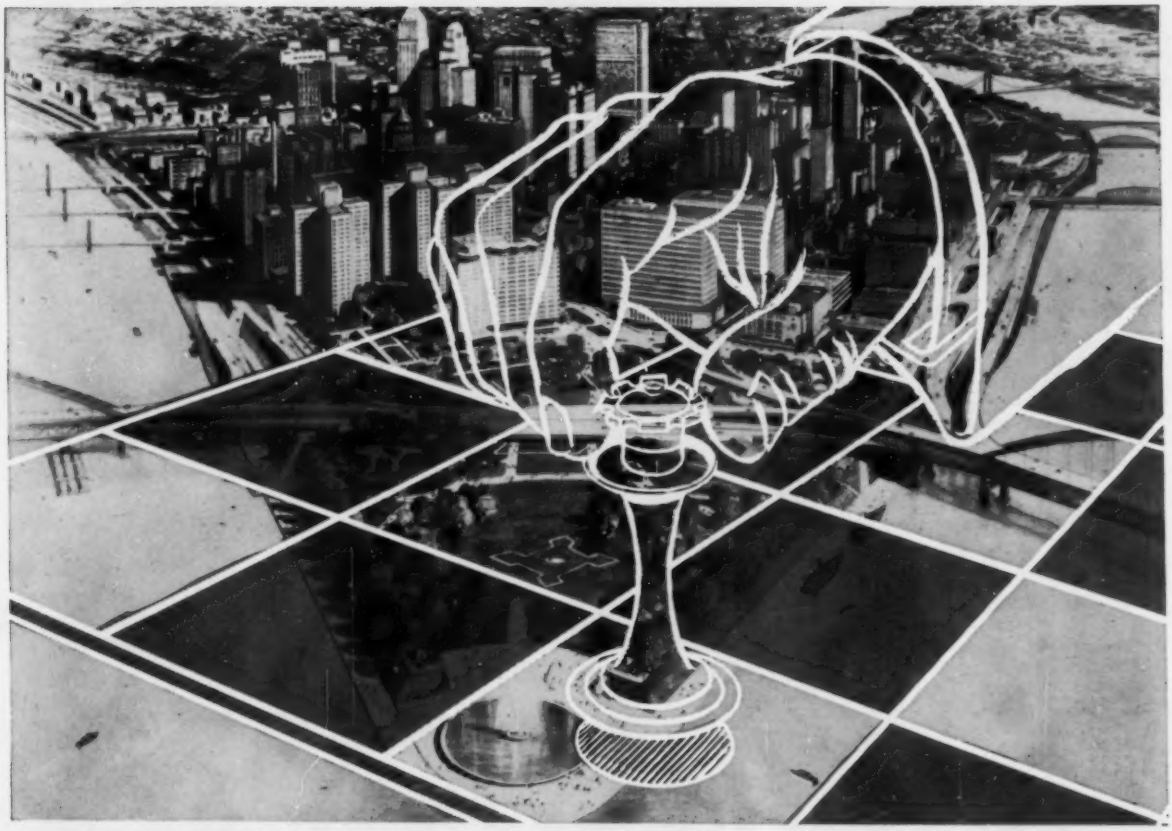
IRON AND STEEL DIV., 1050 IVANHOE ROAD, CLEVELAND 10, OHIO

In Canada—Bailey Meter Company Limited, Montreal

INSTRUMENTS AND CONTROLS FOR POWER AND PROCESS

BAILEY METERS

BAILEY BUILDING BLOCK METHOD



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It's the wise engineer who is making the move to WESTINGHOUSE—PITTSBURGH. Not only is he contributing his talents to the important task of building America's ATOMIC FLEET, but he is experiencing the wonders of living in the NEW Pittsburgh. No city in the United States has undergone the metamorphosis of this great metropolis; and the extraordinary results are evident everywhere—from the new, safe, wide highways to the delightful tree-lined, residential communities. For a way of life that is truly fit for a "king", the smart move is to PITTSBURGH, and an ATOMIC POWER career with WESTINGHOUSE.

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For liaison. Power Plant machinery layout. Some stress, supervise final installation. Degree required.

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MANUFACTURING ENGINEERS
Experienced pumps, valves. Work as liaison between engineering department and vendors on centrifugal pumps and other semi-standard centrifugal and positive placement pumps and valves.

METALLURGICAL ENGINEERS
Responsible for materials and processes application to marine nuclear power plants.

Westinghouse
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A
Little
Does so Much!

VANCORAM GRAINAL ALLOYS

Improve hardenability and hot-working characteristics in steels—at pint-sized cost!

No major changes in steelmaking techniques need be made to reap the benefits from economical, efficient Grainal Alloys. What's more, millions of tons of steels produced with Grainal have been the proving ground for these reliable alloys that give such remarkably consistent hardenability results.

And in stainless and heat-resisting steels, small additions of Grainal Alloys improve hot-working characteristics, cut rejections and conditioning costs. The loss of valuable metal through grinding, chipping and scarfing can be kept to a minimum – even in higher alloy grades Grainal offers a low-cost solution to difficult rolling and conditioning problems.

Get more facts about either Grainal No. 79 or Vanadium Grainal No. 1 from your nearest Vanadium District Office — and write today for your FREE copy of "Grainal and its Uses."

Be sure to see us at the AIME Open Hearth Meeting in Pittsburgh, April 8-10!

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VANADIUM CORPORATION OF AMERICA

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Producers of alloys, metals and chemicals

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Over their entire pressure range, Microvac pumps give high efficiency . . . are widely used by themselves or as roughing pumps with booster or diffusion pumps. Call the nearest Stokes office for a consultation on your specific vacuum application.

Stokes Vacuum Calculator contains valuable high vacuum data, simplifies calculation of pump performance and selection of pump size for specific applications. Get your free Calculator, by writing to Stokes today.

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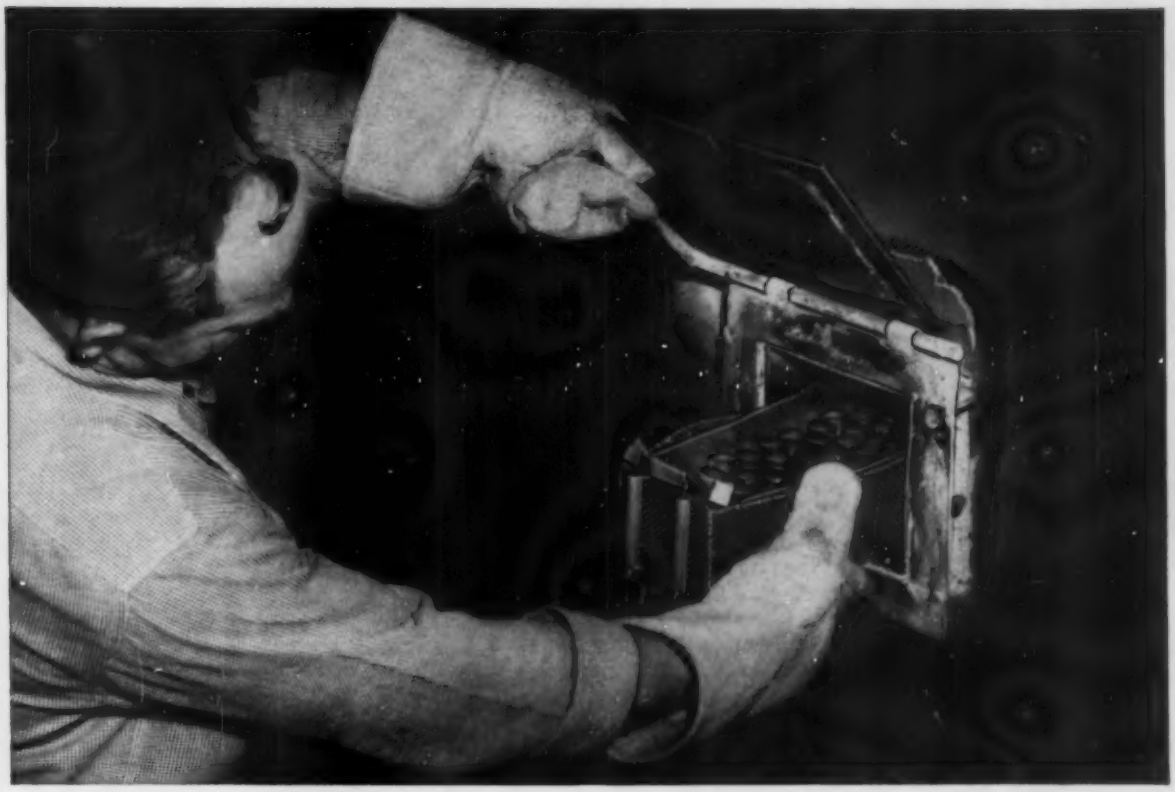
Vacuum Components Division
F. J. STOKES CORPORATION
5522 Tabor Road, Philadelphia 20, Pa.

STOKES



720 Hours at 2300 Deg. F ...Didn't Hurt This Muffle

Continuous exposure at 2300 deg. F had little effect on a muffle made of HASTELLOY alloy X and used in this electric annealing furnace. The muffle was subjected to the intense heat for an entire month, 24 hours a day. After this extended service it was examined, found to be in excellent condition, and put back in service.

Actually, HASTELLOY alloy X solved a dual problem for this Company. The muffle is used in a furnace for annealing cold-drawn parts. Periodically, it is used for annealing superalloy parts at 2300 deg. F. Most of the time, however, it is used to anneal stainless steel parts at lower temperatures. Other materials were either inadequate for this service or too costly. Only HASTELLOY alloy X could handle both conditions economically.

HASTELLOY alloy X is a wrought high-temperature alloy with excellent strength and oxidation resistance to 2300 deg. F. For a copy of a booklet describing HASTELLOY alloy X, get in touch with the nearest sales office listed below.

HAYNES TRADE-MARK ALLOYS

HAYNES STELLITE COMPANY

A Division of Union Carbide and Carbon Corporation

UCC

General Offices and Works, Kokomo, Indiana

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"Haynes" and "Hastelloy" are registered trade-marks of Union Carbide and Carbon Corporation.

Spring steel within this range...

FOR THE MOST EXACTING NEEDS KNOWN TODAY!

• That this is the age of specialization is certainly true in the use of steels. And in this regard *Athenia Steel* customers benefit especially by two not-too-common factors. First, by extreme control of quality and uniformity, unsurpassed, seldom equalled *anywhere!* Secondly, by painstaking technical service to determine or develop precisely the right steel for any special need.

Here at Athenia we concentrate on cold rolled high carbon flat steels, custom made of .45 carbon and higher, in widths from .015″ to 16″ and thicknesses from .001″ to .065″. Full range of finishes and tempers. We also produce special narrow width stainless, and the new super-tough, corrosion resistant spring material, Nilcor*.

For a new and profitable experience in service and in steel controlled precisely to *your* needs . . . try us!

*Trade Mark National-Standard Company

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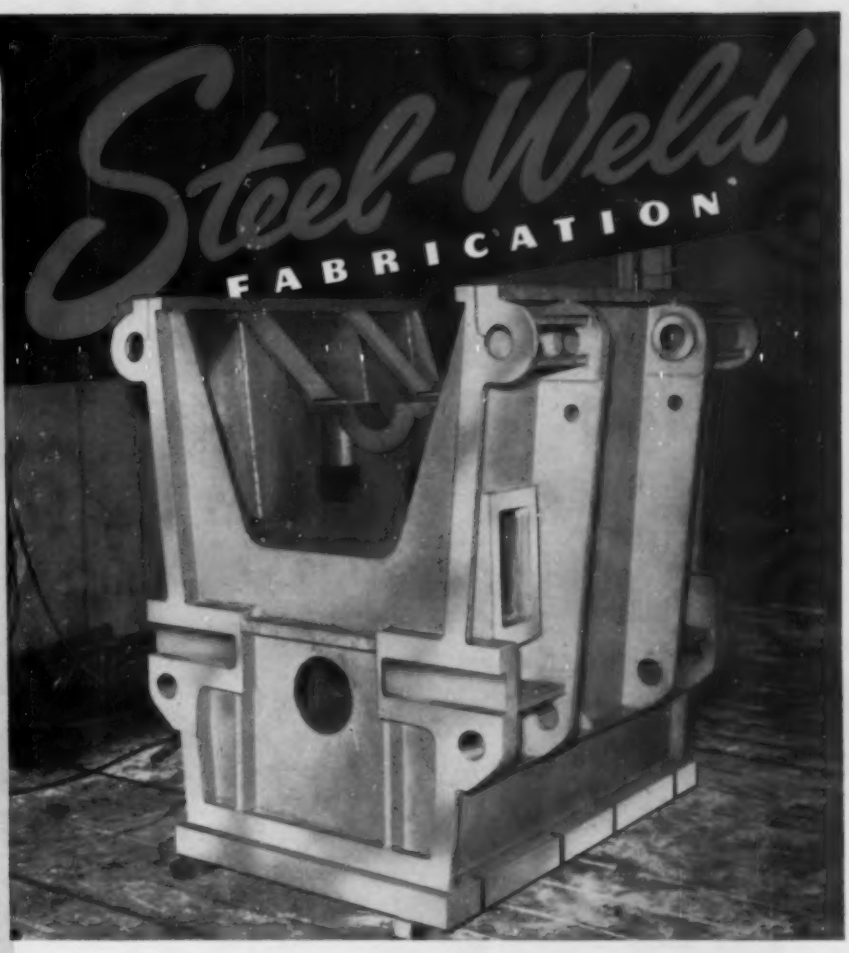
Steel-Weld FABRICATION



Use WELDED STEEL for Greater Strength with Less Weight!

The 35-Ton Weldment above is the Center Section of a three-section Bed for a large Underdrive Press. This piece, and the units illustrated at the left, are typical of thousands of Steel-Weld Fabricated parts and assemblies produced by Mahon for manufacturers of processing machinery, machine tools, and other types of heavy mechanical equipment. It is possible that you, too, could benefit by the economies and other advantages offered by welded steel components in your product. In any type of heavy machinery there are parts and sub-assemblies that can be produced more economically and more satisfactorily in welded steel, because, in weldments you get greater strength with less weight, plus the additional advantages of greater rigidity and predictability. Before you place an order for weldments, you will want to discuss your requirements with Mahon . . . because here is a unique source for welded steel in any form . . . a reliable and responsible source with complete facilities for design engineering, fabricating, machining and assembling . . . a source where advanced fabricating techniques are supplemented by craftsmanship which assures you a finer appearing product embodying every advantage of Steel-Weld Fabrication. See Sweet's Product Design File for information, or, better still, have a Mahon sales engineer call at your convenience.

THE R. C. MAHON COMPANY • Detroit 34, Michigan

Sales-Engineering Offices in Detroit, New York and Chicago

Engineers and Fabricators of Steel in Any Form for Any Purpose

MAHON

NEW HP-30 PYROMETERS offer high accuracy and close reproducible control—yet have been reduced more than 50% in size and 10% in cost.

NEW FROM GENERAL ELECTRIC . . .

Pyrometers that give low cost temperature regulation

Type HP-30 Pyrometers fulfill industrial furnace operators' requirements of close control at **low cost.** Installation and maintenance costs are low too.

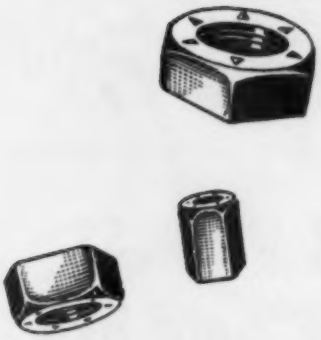
The HP-30 may be connected from front or rear terminals, has automatic adjustment for thermocouple lead length resistance. Plug-in components and printed circuits make possible simple, easy maintenance.

Extremely flexible, the new series of pyrometers also offers flush or surface mounting, interchangeable control forms, and range changes that can be made in the field.

The HP-30 is an adaptable instrument that features a variety of uses. Six basic control forms are available, and special variations to solve specific control problems (speed, vacuum and voltage for example) are available on request.

For further information, write to Section 587-7A, General Electric Company, Schenectady 5, N. Y., or contact your nearest General Electric Apparatus Sales Office.

GENERAL ELECTRIC

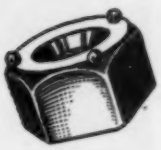


For over 50 years, leading manufacturers in all the major industries have used Gripco lock nuts to simplify production, lower manufacturing and maintenance costs and to improve the durability of all kinds of assembled products. To maintain this enviable reputation for outstanding product quality, the Grip Nut Company of South Whitley, Indiana, uses quality-controlled Youngstown Scrapless Nut Wire and Bars as basic raw material.

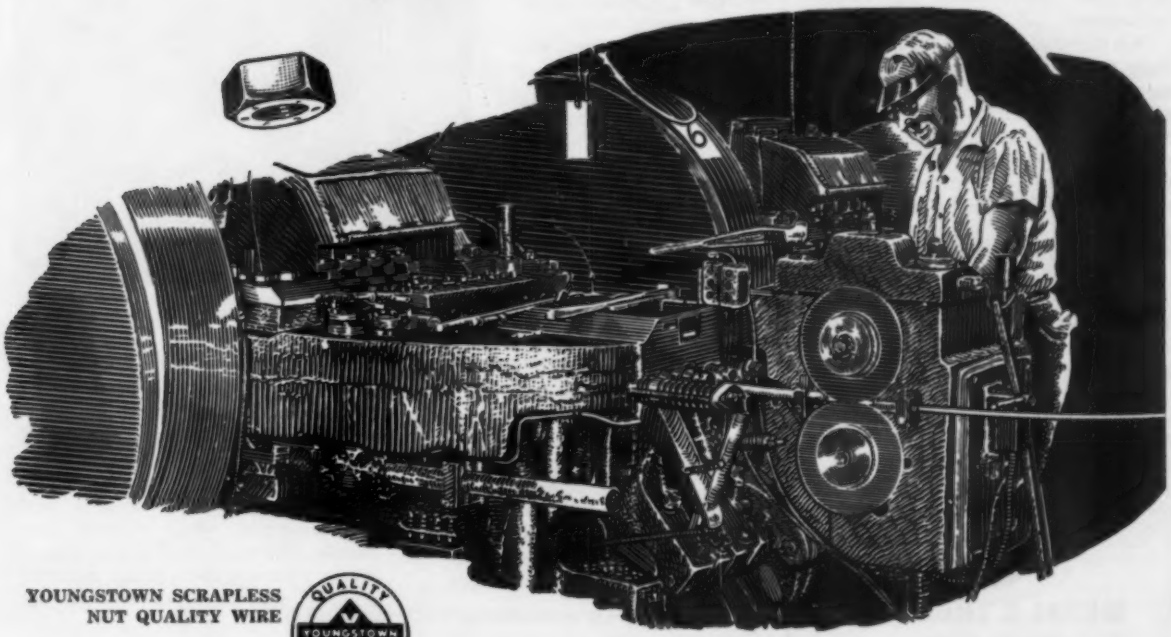
Because it comes to your plant free from all piping, injurious seams, laps, die marks, internal tearing and cupping, and non-metallic inclusions —Youngstown Scrapless Nut Quality Wire will provide increased production with fewer rejects which adds up to a healthy over-all profit boost. Also, its smooth coating extends die life thus minimizing costly die replacements.

YOUNGSTOWN SCRAPLESS NUT WIRE

Helps Maintain Quality of GRIP *Lock Nuts*



Youngstown Scrapless Nut Quality Wire is provided in special resulphurized steels as well as in standard AISI grades. Cold Heading Bolt Wire, of the same high Youngstown quality, is also available in all standard carbon and alloy analyses. Why not phone or write to our nearest District Sales Office for additional information or metallurgical assistance?



YOUNGSTOWN SCRAPLESS NUT QUALITY WIRE

QUALITY YOUNGSTOWN SERVICE

THE YOUNGSTOWN SHEET AND TUBE COMPANY

Manufacturers of Carbon, Alloy and Yoloy Steel

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UNICHROME
Trade Mark

News about
COATINGS for METALS
Metallic.....Organic.....Decorative.....Protective

Simple bronze plating process gives gold-like finish

- ***M&T copper-tin process deposits extraordinary, golden-glow decorative plate . . .***
- ***Also cuts need for nickel as undercoat***

BRONZE plating has proved itself a practical finish in large and small installations. The copper-tin process developed by Metal & Thermit eliminates usual difficulties and disadvantages in alloy plating. It is as easy to operate and control as normal processes depositing a single metal.

Equally important, this bronze can be deposited with brilliant 24K gold color by using a trouble-free brightener. Protected with a clear organic coating, it provides a high quality decorative finish with unusual appeal and long life. Overall cost of this bronze rivals that of copper and is less than that of a brass plate.

M&T Bronze gets the trophies. Golden-glow finish for die cast trophy cups wins over copper-nickel-gold formerly used by leading producer.

VALUABLE UNDERCOAT

As an undercoat, M&T Bronze has these qualifications: Good corrosion resistance; hardness better than copper and virtually equal to nickel; more ductility than nickel.

Undercoat-bronze can be plated semi-bright or matte. Both buff more readily than copper and with less chance of cut-through on edges.

OPERATIONAL ADVANTAGES

M&T Bronze offers better than twice the speed of fast copper plating solutions. There are numerous installations working at normal current densities of 60-75 amps per sq. ft. Densities of 100 amperes deposit over one-tenth mil a minute smoothly.

Golden-glow bronze delivers uniform color on intricate decorative work. So outstanding is its throwing power, it is being used to replace copper on complex automobile parts. It uses single anode circuits, and copper anodes which corrode uniformly. The tin is supplied by potassium stannate additions, assuring simple, economical control of the process.

For an unusual finish, both in appearance and protective function, the golden-glow M&T Bronze Process offers interesting possibilities to metal finishers and designers. Send for data.

New economy in chromate finishing

Several newly developed Unichrome Dip Compounds work at extreme dilutions. They offer chromate solutions with still lower make-up and operating costs than previously delivered by economical Unichrome Dips. These new Dips make it practical to preserve shelf life and appearance of galvanized, zinc plated or die cast items, even those having low unit price or narrow margin of profit.

MATCHED TO THE NEED

Unichrome Dip Solutions form corrosion-resistant finishes integral with zinc, improve and protect its eye appeal.

But chromate dips are active solutions which strip away zinc as well as convert its surface into an attractive but inactive film. As a result, the type of equipment used and the operating time or cycle affect results. The differing needs of manual or automatic finishing must be satisfied to produce the color, corrosion resistance, uniformity of finish—as well as the economy desired. Since no single chromate solution is equally suitable for all applications, many specialized Unichrome Dip Compounds are made available.

Metal & Thermit will gladly recommend the proper dip to meet specific needs. Simply submit details of product and requirements.

Unichrome is a trademark of Metal & Thermit Corp.

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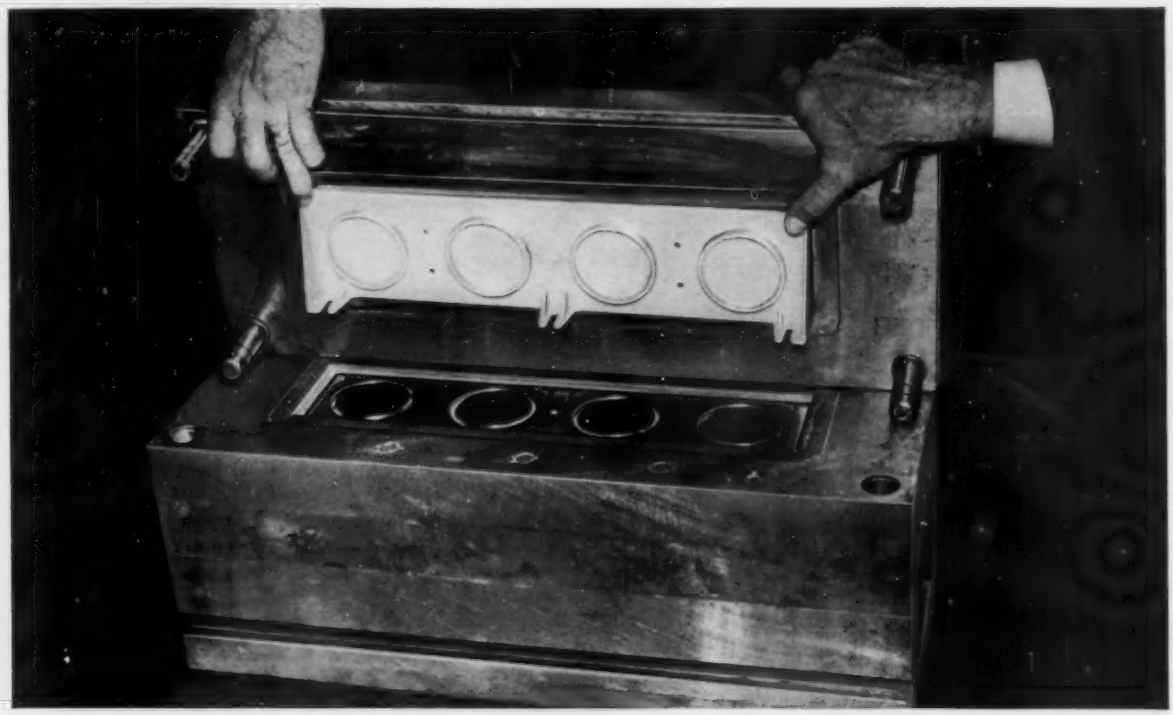

Unique, "spin-out" mold, shown at Leaf Plastics, Yonkers, N. Y., pioneers in this type of injection molding.

UHB-151 Tool Steel Meets Severe Demands Of "Spin-Out" Injection Mold

More and more die makers are solving their difficult job needs with Uddeholm tool steel. The interesting injection mold above is a good example. It produces a high impact styrene utility shelf with four, threaded jar caps. Making such a mold required a tool steel of exceptional quality.

Diemakers, Inc., of New York City, found just what they needed in Uddeholm's air hardening UHB-151, a tool steel of excellent machinability. The properties of this steel enabled it to take the finely polished surfaces necessary for injection molding—before and after hardening. High stability in hardening insured exact dimensional accuracy of the threads—so that jars would always screw in easily and correctly. It also provided perfect meeting of all sides and corners to prevent flashing. And extremely high wear resistance guaranteed the production life needed for a long-run, consumer product.

Uddeholm's Swedish-quality tool steels will prove an asset to *any job*. Why not take advantage of them for *yours?* Stocks include over 2800 combinations of size, shape, grade and finish. A telephone call will start your steel on the way.

Plastic "Wonder Shelf" sold by Goodman Bros., Inc., Meriden, Conn.

Write for Tool Steel Stock List No. 12

UHB

UDDEHOLM COMPANY OF AMERICA, INC.

Tool and Die Steels
Specialty Strip Steels

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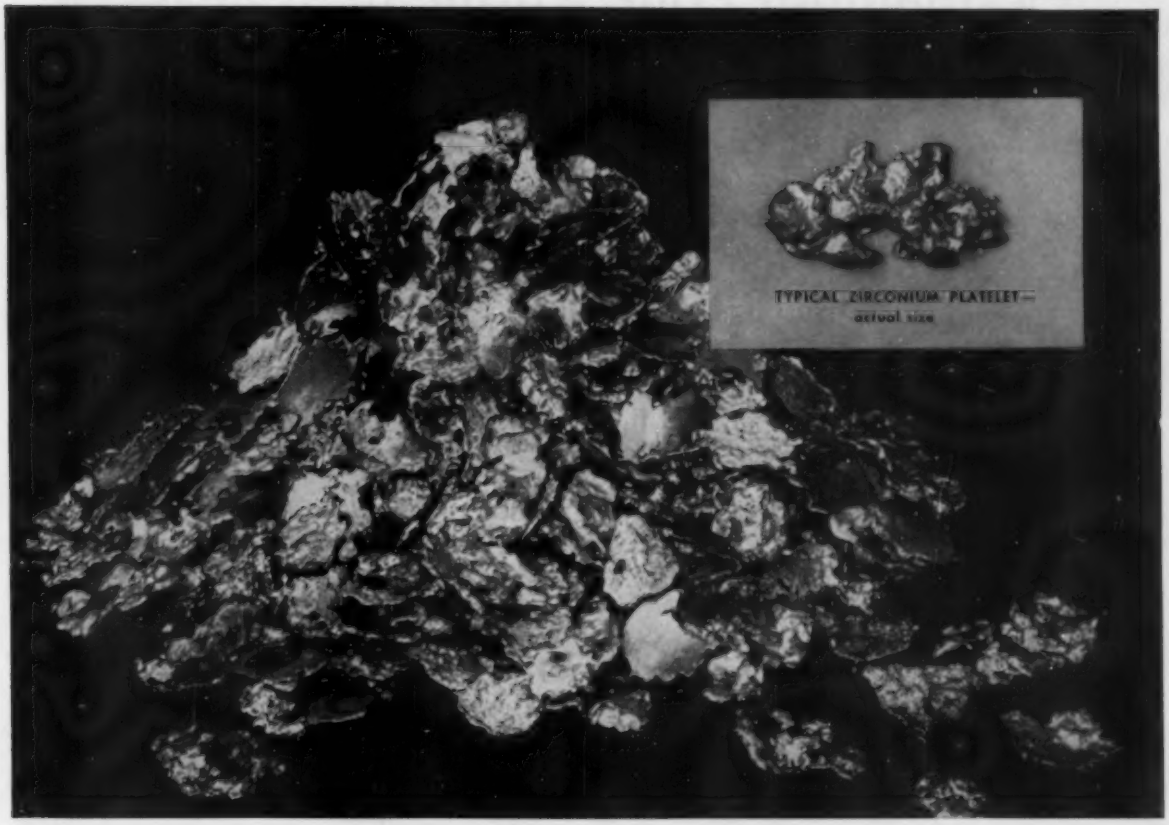


Available soon at lower prices . . .

A MILLION POUNDS OF ZIRCONIUM FOR INDUSTRIAL USE

By mid-1957 zirconium users can get 1,000,000 lbs. a year of the metal from a new U.S. Industrial Chemicals Co. plant at Ashtabula, Ohio. In a new, non-pyrophoric, non-hygroscopic platelet form U.S.I. zirconium has these advantages over the more familiar sponge metal: it eliminates safety problems in handling and shipping, and it permits a cleaner, safer melting operation.

Lower Price

Reactor grade will be priced at $4.75 to $6.50 a pound, depending on quantity. Commercial grade will sell at about $1.50 less. These low prices will be possible because U.S.I., as a prime producer of sodium metal, uses a semi-continuous sodium reduction process—the most economical production technique ever developed for reducing metallic chlorides.

Higher Quality

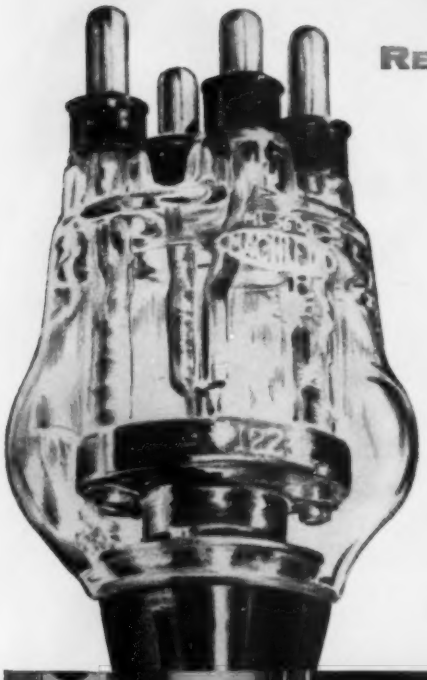
U.S.I. zirconium will offer users top quality, too. In the first place, U.S.I. starts with sodium, a higher purity raw material than the reducing agents commonly used in other processes. Then, the technique itself yields a product of higher purity and uniformity. Finally, in making its zirconium platelets U.S.I. virtually eliminates chloride, magnesium, sodium and hydrogen impurities.

Small quantities of commercial grade material are available for immediate delivery. To help you on applications U.S.I. has a staff of metal experts. Call Bill Greenleaf, Manager of Metals Department, for further information.

U.S.I. INDUSTRIAL CHEMICALS CO.
Division of National Distillers Products Corp.
99 Park Avenue, New York 16, N. Y.

Chemical Progress Week — April 8-12

Germanium Zone Purification at **IBM**



RELIES ON R-F INDUCTION HEATING WITH

Machlett ML-5606

INDUSTRIAL OSCILLATOR TRIODES

At International Business Machines Corporation—Poughkeepsie, transistors are made for IBM's Transistor Calculators which perform arithmetical operations at speeds twice those of previous models. Transistor fabrication depends on zone purification and crystal drawing. If it were not for r-f induction heating these operations would be difficult to accomplish, if, indeed, they could be done at all. As original oscillator tube components, Machlett ML-5606 triodes power the 10kW r-f induction heaters used on a rigorous schedule in IBM's Transistor Fabrication Department.

Crystal Drawing

Germanium Zone Purification

Quality Control Note — Machlett X-Ray Tube

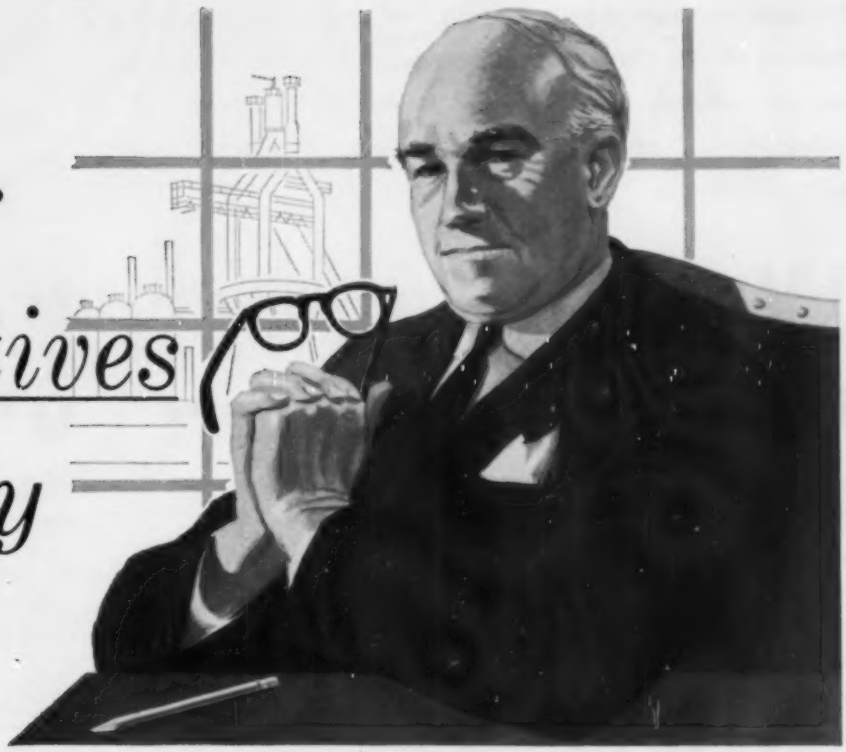
A Machlett Industrial Thermax X-Ray tube—on full schedule for 5 years, including 1½ years of two shift work—has helped IBM Military Products Division, Receiving Inspection maintain quality standards for the many castings, forgings, and assemblies it requires.

MACHLETT

FIRST IN INDUSTRIAL ELECTRON TUBES

MACHLETT LABORATORIES INC.
Springdale, Connecticut

For Executives Only



- Interested in producing low-carbon steels
- Decreasing production man-hours
- Increasing shippable yields

Man-hours of production cost and shippable yields now afford the steel producer just about the only opportunity for improvement to meet price and quality competition.

The addition of but small quantities of MCA rare earth materials frequently results in valuable savings in surface preparation costs and increased shippable yields, both of which have been demonstrated in production runs. Plate steels, deep-drawing sheet steels, low-carbon steels, silicon and stainless steels, and steels demanding transverse properties are among those especially susceptible to improvement with rare earths.

The substantiated proof of rare earths in steel-making economy and MCA's technical knowledge are unsurpassed. Write or call today for details.

MOLYBDENUM CORPORATION OF AMERICA

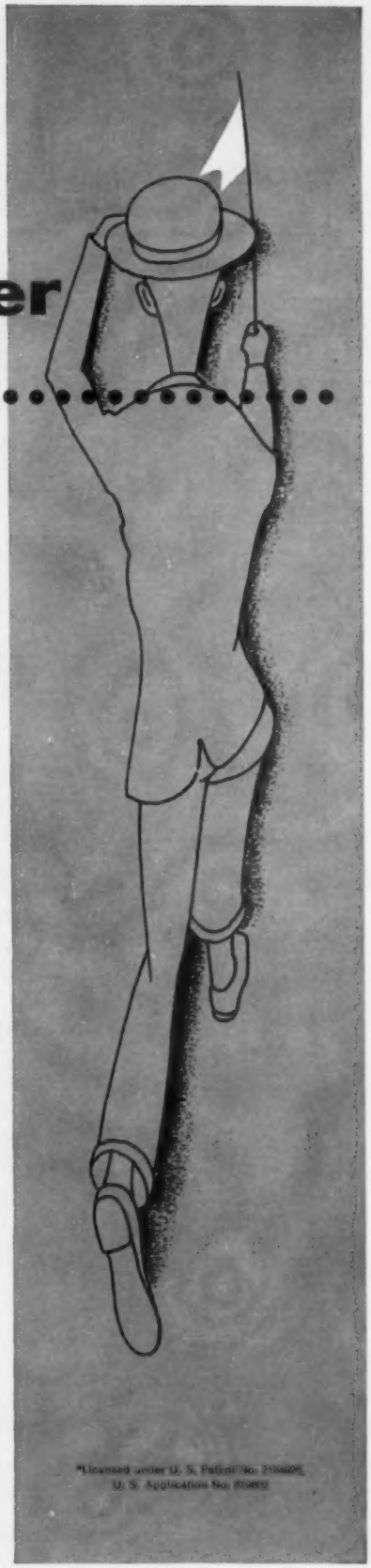
Grant Building **Pittsburgh 19, Pa.**

Offices: Pittsburgh, Chicago, Los Angeles, New York, San Francisco
Sales Representatives: Brumley-Donaldson Co., Los Angeles, San Francisco
Subsidiary: Cleveland Tungsten, Inc., Cleveland
Plants: Washington, Pa., York, Pa.

MCA

For many years now, there has been a surge of movement towards National Metal's *Controlled*, premium abrasives: Permabrasive, pearlitic malleable shot and grit where annealed abrasives are indicated and Controlled "T" SHOT and grit, where fast cutting action is desired.

Why be a tail-ender at a parade? .....



The parade of users has grown to sizable proportions—and why not? Controlled "T" is an unique shot and grit: the iron carbides are held in a ductile matrix, producing extremely fast cutting action coupled with long life, resulting in astounding savings in maintenance. Controlled "T" is the *only* low-priced shot that deforms instead of shattering when hit with a hammer! That's why this premium shot carries a written guarantee to save you at least 15% on abrasive costs figured on the price you are *now* paying!

On top of your 15% savings on abrasives alone—you also get that *added extra*—the savings on maintenance, that's all gravy—could be 20% or more—a *big bowl* of gravy!

You can prove this to *your* satisfaction *without* a formal test!

IT COSTS NOTHING

It will cost you nothing to get the full low-down on all our statements, except a 3¢ stamp. Your savings may be substantial . . . worth the effort of finding out. Write for any of three free booklets:

1. **"Tired of Testing"**—how to establish wheel-hour costs without routine-upsetting tests.
2. **"It's Triplets"**—all about clinch-locked 50 lb. palletized cartons at no extra cost.
3. **"The Primer on the use of shot and grit"**—a basic explanation of the complex blast cleaning operation.

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PERMABRASIVE* PEARLITIC MALLEABLE SHOT AND GRIT IS PRODUCED EXCLUSIVELY BY

NATIONAL METAL ABRASIVE COMPANY

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Every pound costs less to process in long-lasting Inconel alloy neutral salt pots properly fabricated and inspected.

INCO NICKEL ALLOYS

This wrought Inconel pot stayed hot eleven months, without failure

Think how this cuts salts bath operating costs

Neutral salt pots aren't usually expected to last 8000 hours. But carefully fabricated wrought Inconel* nickel-chromium alloy pots have.

Take *this* one. When the above photograph was taken it had been going for eleven months without shut-down. During this period it was operated at the customary 1500-1600°F, idled at about 1350F°.

The users, A. F. Holden Co., (Detroit Plant) had never previously used a wrought Inconel Alloy pot. So they're pretty enthusiastic about this one. It's brought their pot costs way down. And it's been a relief and a saving not to tear down the installation for frequent pot replacement.

Fabricated by Misco

Salt pots owe as much of their success to good fabrication as to the properties of the alloy used.

Recognizing this, the Holden Co. ordered this pot and, later, a stand-by successor from Misco Fabricators.

Misco skillfully formed and welded both under proper conditions . . . then X-ray inspected them.

You can ask a good deal of wrought Inconel alloy that has been properly fabricated. Not only for neutral salt pots but for most equipment subject to severe corrosive attack and prolonged high temperatures.

*Registered Trademark

The International Nickel Company, Inc.
67 Wall Street New York 5, N. Y.

Inconel... *for long life at high temperatures*

Custom Tailoring a Silica Product to Size!

RCA Electron Microscope Provides National Aluminate Corporation with the Satisfactory Way to Measure Size of Silica Particles in "Nalcoag."*

Silica particles in "Nalcoag." Magnification 65,000X.

The effects of various particle sizes in this product's stability and performance were known. But, until the RCA Electron Microscope was used, there was no satisfactory method of measuring the *size* of the particles. Now, with the electron microscope it's easy! And "Nalcoag" can be produced in the particle size most suitable for the use intended. This is a product improvement directly traceable to microscope studies. The RCA Electron Microscope is also used by this company for other particle size determination, for studies of diesel fuel and miscellaneous research.

Electron Micrograph of sludge particles in diesel fuel oil. Oil treatment has been improved considerably by new information obtained on the character of sludge-forming materials.

Hundreds of RCA Electron Microscopes are already in use. They have opened many new avenues of exploration in the field of chemistry, metallurgy, medicine, bacteriology and biology. The technique of operation is readily acquired by any competent technician. Compact, one-piece units, these amazing microscopes can provide useful photographic enlargements up to 300,000X.

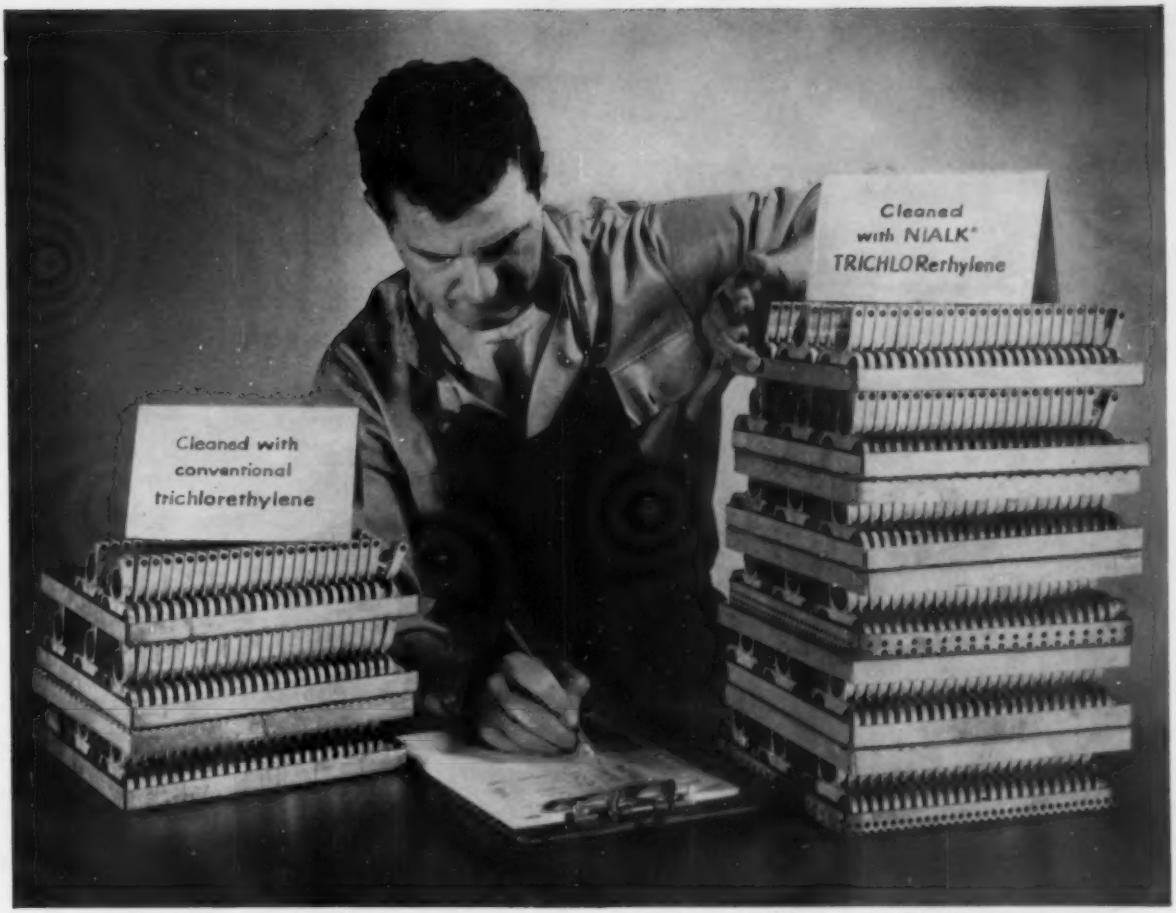
For further information on the Electron Microscope, write to RCA, Dept. R-72, Building 15-1, Camden, N.J. In Canada: RCA VICTOR Company Ltd., Montreal.

**Registered trademark of National Aluminate Corporation for a colloidal silica, used as a binder in making molds for precision investment casting.*

Tmk(s) ®

RADIO CORPORATION of AMERICA

Camden, N. J.



Operator using NIALK *TRICHLORethylene cleans more parts, because* NIALK *has* **psp** *which prevents acid contamination, reduces number of cleanouts.*

Why you get more effective degreasing when you use Nialk® TRICHLORethylene with psp

There's a difference—a big, cost-cutting difference—between NIALK TRICHLORethylene and conventional vapor-degreasing solvents.

Light, heat, air, acids, and active metals such as aluminum, given time, can break down improperly stabilized trichlorethylene, making it unfit for further degreasing.

Only Nialk TRICHLORethylene has psp

The stabilizer in NIALK TRICHLORethylene has **psp**—permanent STAYING power. It's neutral, non-alkaline. You *never* have to replenish it.

Only NIALK has this *permanent staying power*. Even after repeated distillations, its unique stabilizer prevents acid formation and other causes of breakdown. NIALK works equally well with *all* metals.

psp means cheaper degreasing ... here's why

You don't have to clean out your degreaser nearly so often with NIALK TRICHLORethylene. You can degrease many more parts between cleanouts.

The NIALK stabilizer actively retards formation of degradation products in your degreaser—cleanouts are easier, faster.

Get proof of Nialk's cheaper, safer degreasing

See for yourself how NIALK TRICHLORethylene with **psp** stays stable, keeps cleaning efficiently long after other solvents have lost their punch. Write on your business letterhead for a revealing resumé of comparative metallurgical tests on the five leading brands.

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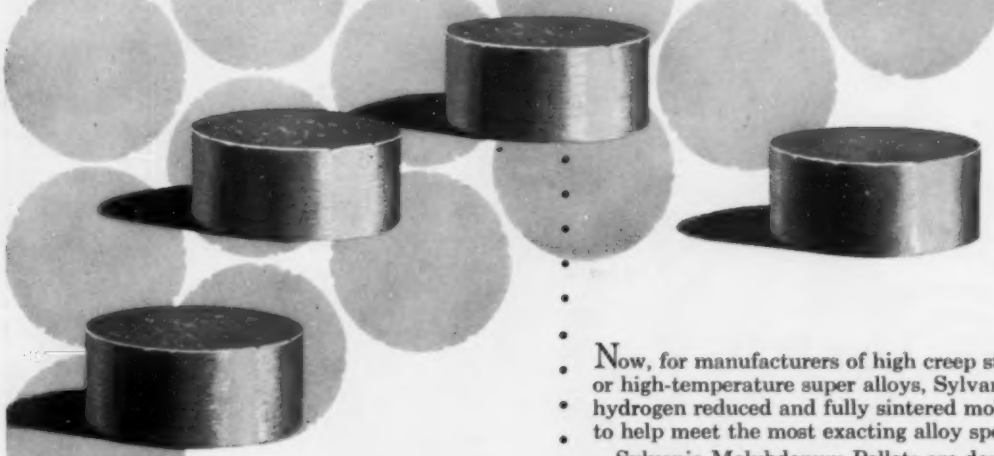
Manufacturers of VIRGO® DESCALING SALT, VIRGO ELECTROLYTIC SALT, VIRGO MOLTEN CLEANER

To help you meet rigid production specifications . . .



Sylvania 99.5% Pure MOLYBDENUM PELLETS

for Super Nickel, Chromium, and Cobalt-base Alloys

Now, for manufacturers of high creep strength alloys or high-temperature super alloys, Sylvania offers hydrogen reduced and fully sintered molybdenum pellets to help meet the most exacting alloy specifications.

Sylvania Molybdenum Pellets are designed specifically for use in vacuum melting operations. They provide a readily available source of molybdenum having a purity of at least 99.5%—typical purity is 99.85%. This constant high purity simplifies the calculation of additions to each melt as the usual variations of purity and gas content are eliminated. By maintaining a high density, the gas content of the pellets is kept well below that acceptable for vacuum melting. In addition, the compact uniform size of the pellets (1″ in diameter by ½″ high) facilitates weighing and charging to the melt.

When you use Sylvania Molybdenum Pellets, you benefit in other ways, too. Their continuous availability means you can plan your production schedules on a long range basis. Further, their pricing stability permits you to price your own product without having to worry about fluctuating raw materials costs.

Your Sylvania sales engineer will be glad to discuss your molybdenum requirements or the high-purity tungsten available in sintered ingot form for vacuum melting. For further information, write to:

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Tungsten and Chemical Division, Towanda, Penna.
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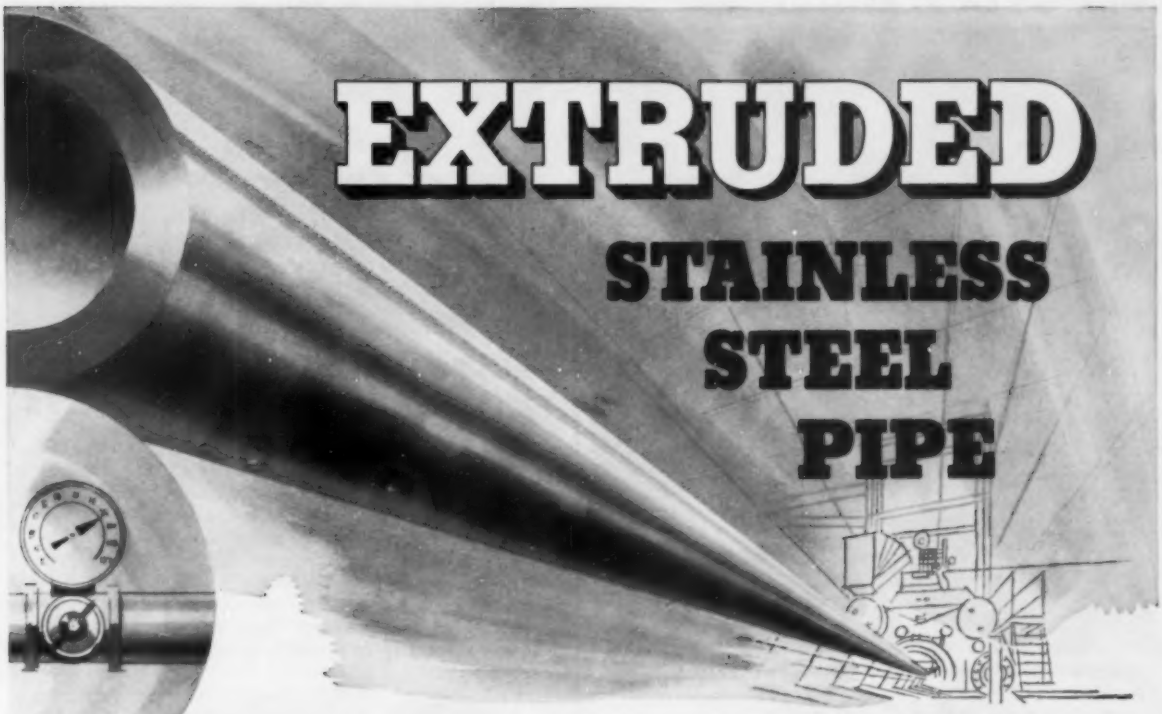

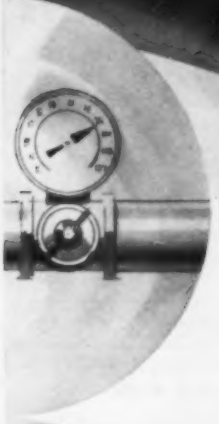

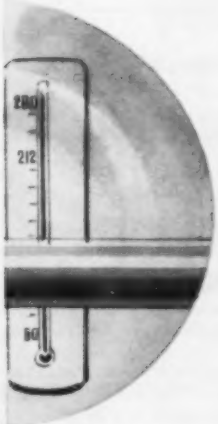

...for maximum service in high pressure, heat and corrosion applications

- Type 310 and 316 alloys
- 10 to 20 inch diameters
- Lengths to 50 feet
- Schedule 40 and heavier wall thicknesses

High Integrity Pipe, for the toughest applications of the power, petroleum, chemical, and other industries, is now being *extruded* at the Metals Processing Division of Curtiss-Wright. In the Division's giant 12,000-ton horizontal steel extrusion press, the inherent properties of stainless steel alloys are transformed into pipe to your specification under tremendous one-push pressures. The result is uniformly high strength . . . high resistance to pressure, heat and corrosion. Investigate the superiority of this new pipe for your application.

Tooling is in stock for prompt action on standard requirements as listed above. Inquiries are invited regarding special orders for diameters smaller than 10 inches and for alloys other than the standard 310 and 316.

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WHAT'S NEW AT BRISTOL...

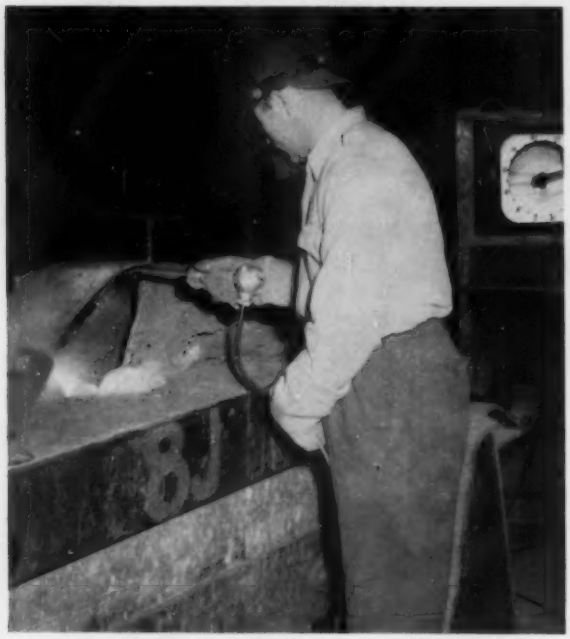

Photo courtesy General Thomas J. Rodman Laboratory, Watertown (Mass.) Arsenal.

NEW!

Immersion thermocouple for molten metals measures to 3200 F

The new Bristol portable immersion-type thermocouple is designed for direct measurements in melts of both ferrous and non-ferrous metals. Simplicity and operating economy are its key features.

Rugged tubes give economy. Latest result of Bristol's continuous development program in instruments and accessories for pyrometry, the new thermocouple's durable protection tube can take up to 14 dips in molten steel at 2700 F to 3200 F. Metals of lower melting temperatures such as brass and aluminum will give far longer life. What's more, replacement of the protection tube, plus reasonable care, allows re-use of the platinum sensing element—most expensive part of the unit.

Standard and "high-speed" models. The standard model of the new thermocouple—full response 30-45 seconds—features a Bristol metal-ceramic (LT-1) secondary protection tube. A special "high-speed" model—response 15-20 seconds—has a single quartz protection tube with quick-change thumbscrew, designed for easy replacement.

STOCK PARTS CUT COSTS, SPEED SERVICE

All parts in the new molten metal thermocouple are stock parts—a product of Bristol's careful design and advanced manufacturing methods. Result: lower first cost due to production economies and faster delivery on replacement parts.

Write today for complete data on this outstanding Bristol contribution to instrumentation in metallurgy. The Bristol Company, 155 Bristol Road, Waterbury 20, Connecticut. 7.1

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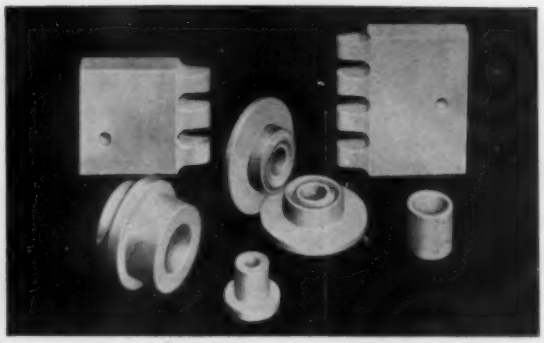
AUTOMATIC CONTROLLING, RECORDING AND TELEMETERING INSTRUMENTS



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● If your controlled atmosphere furnaces need High Temperature insulators, see McDanel. Don't be restricted by standard sizes and design. We'll make spools, separators and other insulators to your specifications; Ceramic Muffle tubes, too. High Temperature Porcelain for temperatures to 2900° F., Pure Alumina up to 3600° F.

Materials selected and recommended for compatibility with your windings. Send us your specifications and a summary of operating conditions.

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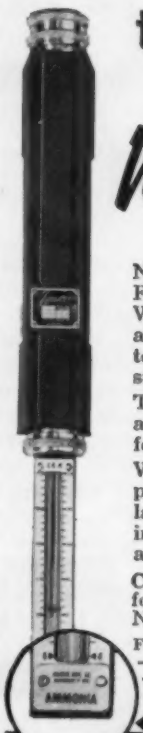

the meter with the tell-tale TAB

Waukee

FLO·METER

No one can mistake what gas the Waukee FLO-METER is measuring — because a Waukee TAB with large RED letters is affixed to the bottom of the scale and *shouts* to your operator whether the meter is measuring hydrogen, ammonia, or any other gas.

TABS are available for all gases listed below, and many others — an exclusive Waukee feature.

Waukee's TABS, built-in Control Valve, panel-mounting design, 5-minute cleaning, large easy-to-read scale — all mean simple installation, clean appearance, accurate operation. Time and money-saving features.

Complete information in Bulletin 203. Write for it. **Waukee Engineering Company**, 5140 North 35th Street, Milwaukee 9, Wisconsin.

For measuring: air — ammonia — dissociated ammonia — argon — butane — city gas — endothermic cracked —exothermic cracked — forming gas — helium — hydrogen — natural gas — nitrogen — oxygen — propane.

Waukee FLO-METERS • AIR-GAS MIXORS INDUSTRIAL WASHING MACHINES

Facts to consider when you're buying

Chromate Conversion Coatings

for Corrosion Protection, Paint Base, Decorative Finishing

WHAT IS IRIDITE®?

Briefly, Iridite is the tradename for a specialized line of chromate conversion finishes. They are generally applied by dip, some by brush or spray, at or near room temperature, with automatic equipment or manual finishing facilities. During application, a chemical reaction occurs that produces a thin (.00002" max.) gel-like, complex chromate film of a nonporous nature on the surface of the metal. This film is an integral part of the metal itself, thus cannot flake, chip or peel. No special equipment, exhaust systems or specially trained personnel are required.

If your company is manufacturing or buying parts or complete assemblies made from or plated with any of the more common non-ferrous metals—zinc, cadmium, aluminum, magnesium, silver, copper, brass or bronze—you've probably already run up against the question of finishing these surfaces with a chromate conversion coating. These coatings are used to protect against corrosion, or to provide a base for paint or to provide a decorative finish for sales appeal or shelf life. Since chromate conversion coatings represent a relatively new means of obtaining these finishes, this digest of facts to consider may be of value to you.

1. THE COATINGS THEMSELVES. There are many brands on the market. All are similar in many ways. Each, of course, offers its own specific advantages and these may relate to operating techniques, performance under actual use conditions, cost, availability, etc. Naturally, you'll want to choose a coating that is widely known and accepted under both military and civilian specifications.

2. THE COMPANY BEHIND THE PRODUCT. Is it a reliable, established organization? Does it offer experienced technical service, both from the field-engineering organization as well as the home office and laboratories? The man who sells and services your installation should be thoroughly familiar with not only chromate conversion coatings and their applications, but also with the characteristics and performance of related finishing operations such as precleaning, electroplating, painting, etc. This is most important since all steps of the finishing cycle must be functioning properly for the satisfactory performance of the ultimate finish produced.

3. AVAILABILITY OF THE PRODUCT. Ideally, of course, the material should be readily available to you from nearby warehouses to avoid time loss in long distance shipping and to provide emergency service, should the need arise.

4. COST. Naturally, the initial price of the material is important to you. However, just as you consider ultimate cost when you are buying mechanical equipment, ultimate cost must be considered for these finishing chemicals. So, it will pay you to investigate consumption costs, labor costs and the other factors which go into the determination of ultimate cost. Further, cost alone gives no indication of product performance, so careful attention must be given to the purpose the finish must serve and the value that finish will add to your product.

5. FACILITIES FOR RESEARCH AND DEVELOPMENT. Perhaps the existing types of chromate conversion coatings do not include a compound that will accomplish exactly what you wish. Then, it is important to deal with a supplier who has adequate research and development facilities available to work with you to produce a material to meet your needs. Naturally, such a project is seldom completed overnight. But, with complete cooperation and confidence from both you and your supplier, chances are a satisfactory program can be completed.

These are the concepts of sales and service on which we, Allied Research Products, Incorporated, have developed and marketed the line of Iridite chromate conversion coatings . . . superior product performance, complete sales and technical service, easy product availability, economical cost, extensive research and development facilities. No doubt you are familiar with our line and have seen this trademark—

IRIDITE®

—in our advertising, technical literature or on shipping containers in your plant. Remember this trademark when you're buying or investigating chromate conversion coatings for your company. It's your assurance of quality, economical products from a reliable and established company, skilled sales and technical service from both our home office and a national network of representatives, immediate availability from warehouses in strategic industrial areas and our willingness to work with you to develop new finishes to meet your needs, should the present line fall short.

For complete information on Iridite chromate conversion coatings, write today for your free copy of our technical data file. Or, for immediate advice, call in your Allied Field Engineer. He's listed under "Plating Supplies" in your classified telephone book.

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Meet all your high temperature heating needs with a Fast, Versatile HARROP Electric Furnace

NMR-20 Standard Harrop Furnace with Instrumentation and Control Unit

In testing, research or small-scale production, Harrop "standard" and "special" furnaces provide increased operating efficiency . . . more accurate temperature control. Standard NMR-20 model (above) has 20" x 20" x 24" setting space; temperature range to 2800° F.; silicon carbide resistor heating elements; blower for accelerating the cooling cycle.

Instrumentation on standard model includes program controller, 6 tap switches and selector switch for instrument or manual control, or blower cooling. Instrumentation may be varied to meet your need.

Other standard Harrop models of similar design cover range of setting spaces from 12" x 12" x 17" to 36" x 36" x 40"

NMR-7 (7" x 7" x 9" setting space) and NMR-10 (10" x 10" x 11" setting space) built in this compact design with optional instrumentation.

SPECIAL FURNACE APPLICATIONS demanding an unusual shape or size of firing chamber, variation in door opening, temperature range or other specific requirement will be designed and built by Harrop. Depend on Harrop's years of experience and engineering knowledge to solve your problem with a soundly designed, neatly built and economical furnace designed and equipped to your special requirements.

For non-obligating recommendation, send information on materials, temperature range, heat control and firing objectives to: **Dr. Robert A. Schoenlaub, Technical Advisor.**

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SIMPLYTROL AUTOMATIC PYROMETERS

For Control of Temperature

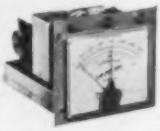
10 standard ranges from −200° to +3000° F.

Accuracy 2% (limit of calibration error).

Sensitivity 4 ohms per millivolt.

Cat. No. 4535, size 10" x 6" x 7". Range 0/1000° F,0/500°C. $135.00

Thermocouple-type automatic pyrometer for controlling temperature in furnaces or ovens and manufacturing processes. Leads between Simplytrol and its thermocouple sensing element may be up to 100 feet or more depending on temperature range and lead wire resistance. Load relay, 5 amperes S.P.D.T. Optional heavy duty relays to 40 A.

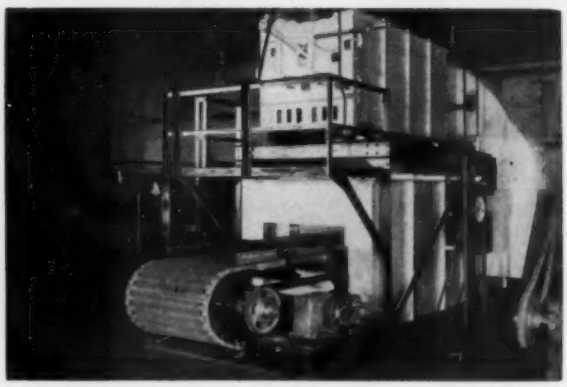


Either AUTOMATIC control or LIMIT shutoff. An automatic Simplytrol turns heat on and off to hold required temperature. Proportioning effect can be increased or decreased by changing cam on the sensing cycle. With shorter cycles, control more nearly approaches straight line. A limit Simplytrol locks up when the trip point is reached and remains locked until reset. Use limit Simplytrols for monitoring and safety shutoff or alarm.

Cat. No. 4532-MFP, size 5"x5½"x8" deep. Range 0/1500°F, 0/800°C. $127.00

Cabinet model for wall mounting or portable shown at top. To the right is an MFP Simplytrol for flush mounting in a cabinet or control panel. Several other mountings are shown in Catalog 4-A. Send for your copy. **Assembly Products, Inc., Chesterland 37, Ohio.** Phone (Cleveland, O.) HAmilton 3-4436 (West Coast: Box XX, Palm Springs 37, Calif. Phone: DHS 4-3133 or 4-2453).

Booth 1323, Design Engineering Show, May 20-23, Coliseum, NYC



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effect large savings in drawing, tempering, ageing, and heat treating of such products as bearings, billets, springs, screws, tools, gears, etc. in steel or aluminum. Continuous operation at temperatures up to 1200° F. Temperature uniformity guaranteed! Gas, oil, or electric fired.

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Exclusive with the Heroult:

Operating Mechanism Independently Supported

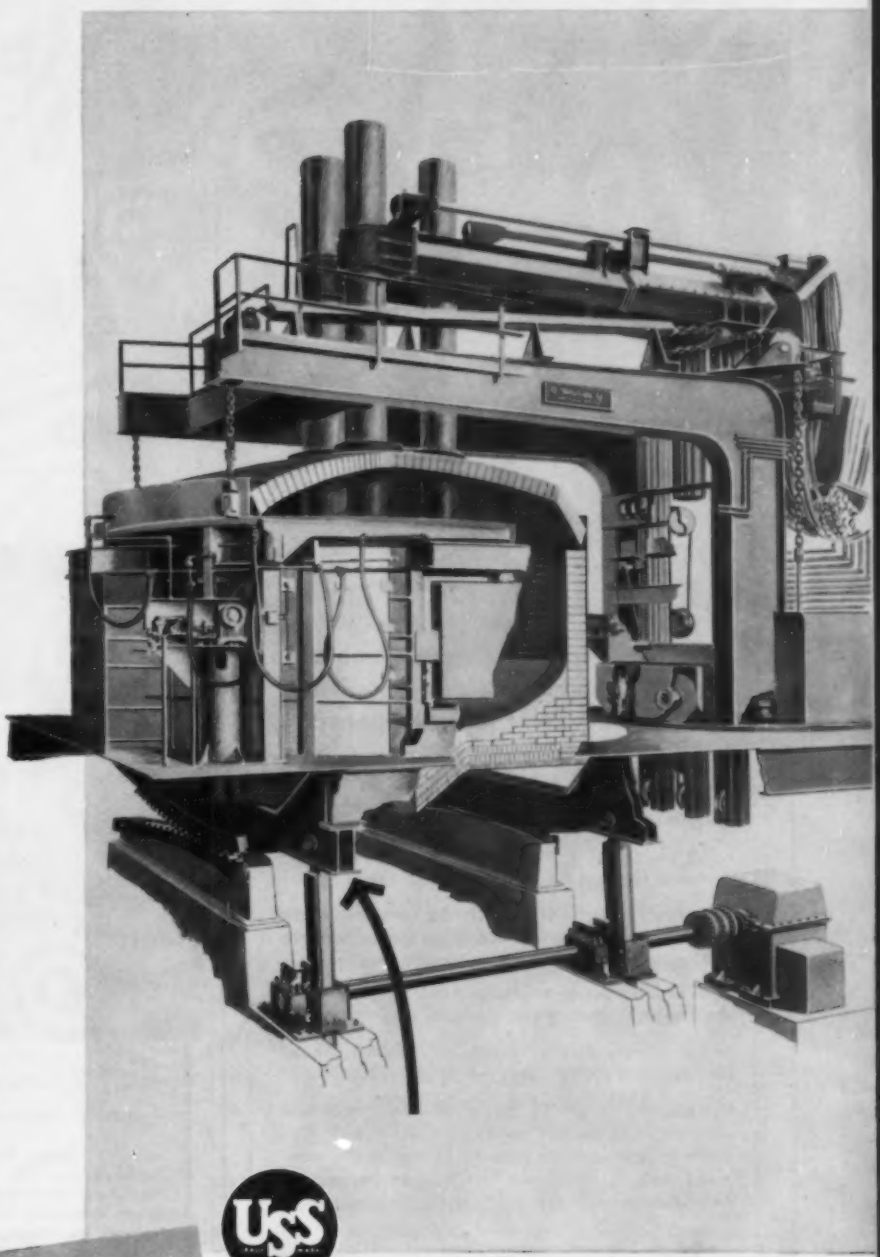
In Heroult's specially designed **new** furnaces the operating mechanism is located on the tilting platform, supported on rockers completely separate from the cage shell. In the event of shell warpage due to overheating, the mechanism remains unaffected and efficient production continues free from maintenance delays.

The independently supported operating mechanism which contributes to lower operating costs, and helps cut maintenance outlays to a fraction of former rates, is only one of the advanced design exclusives offered by the **new** Heroult for increased production efficiency. There are four others ready to operate on your behalf:

1. **Flat-bottom shells, for simplified relining jobs and good bath temperature distribution.**
2. **Water-cooled skew back roof ring, eliminates need for special roof refractories.**
3. **Cage-type shell construction, minimizes shell distortion and facilitates replacement of damaged shell plates.**
4. **100% mechanical operation, for reliability and ease of maintenance.**

There is a wide range of **new** Heroult Furnaces with shell sizes from 7'0" up, and with capacities from 6000 to 400,000 pounds. You can obtain them with non-magnetic induction stirring equipment, top charge, door charge, and special duplexing. Non-ferrous furnaces are also available.

The pioneers and leaders in this field for 51 years, Heroult specialists in electric furnaces can help you select and install the equipment best suited to your current and future needs. Get in touch with our nearest contracting office—today—for complete information.



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99.7% Al_2O_3

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— as insulators for rare metal thermocouples where complete freedom from silica attack is essential

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— as high temperature furnace tubes, particularly for applications requiring an impervious tube

— and as molybdenum, tungsten and platinum wound tube furnaces for very high temperature operation

Morganite Triangle RR (Impervious Recrystallized Alumina) is a ceramic grade of exceptionally high purity. It is snow white in color. Its high purity, combined with its impervious structure of interlocking corundum crystals, successfully resists chemical attack.

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"sectionalized" factory built PERECO CONTINUOUS FURNACES

easily assembled in the field—
—easily dismantled for moving

In either "Sliding Plate" or "Car Type," Pereco factory-built sectionalized electric continuous furnaces are quickly assembled for volume production right on the job location—and just as quickly dismantled for moving or relocating. This new series of furnaces has silicon-carbide elements in three individually-controlled banks and provide accurately controlled operating temperatures of 500° F. to 2600° F. They're supplied complete with hydraulic pusher assembly and all temperature and power controls and are offered in a range of sizes and modifications to meet individual requirements.

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Dept. Q, 893 Chambers Rd., Columbus 12, Ohio

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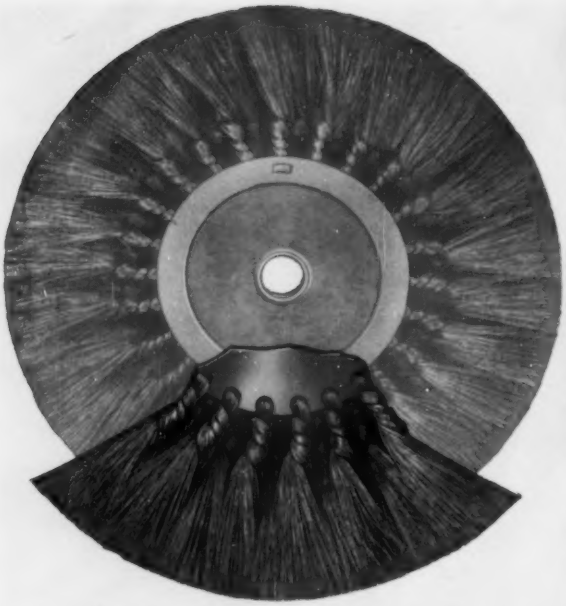

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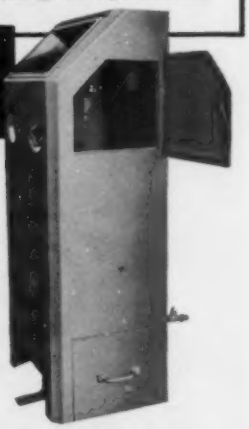

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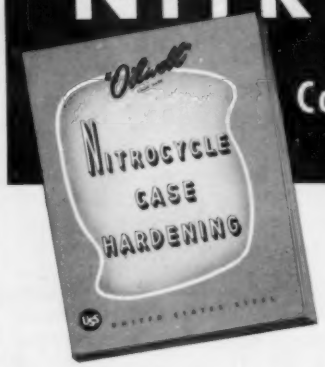

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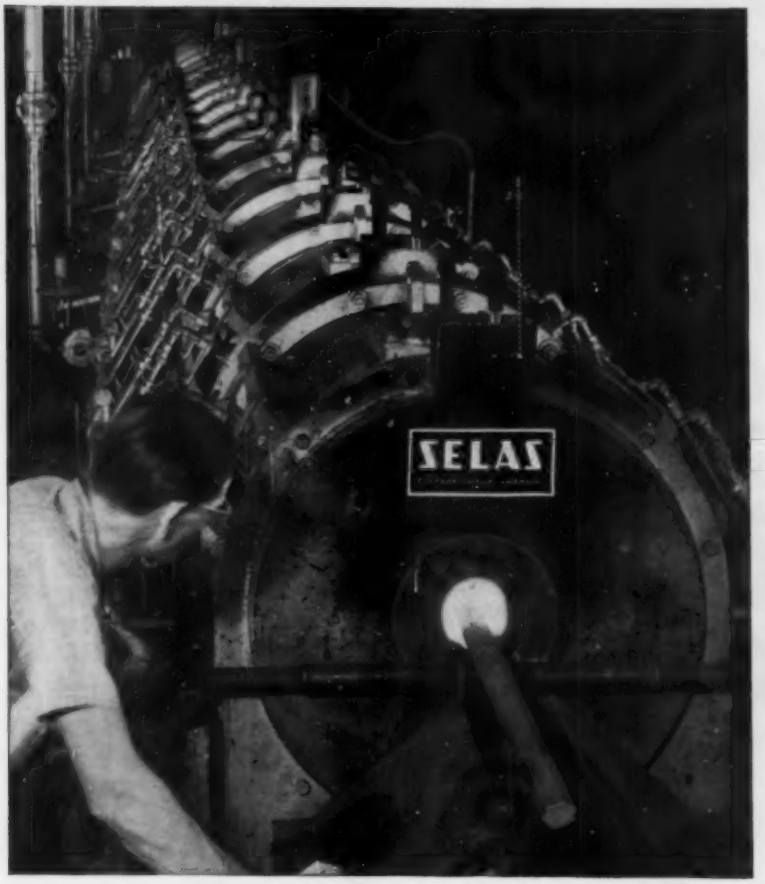

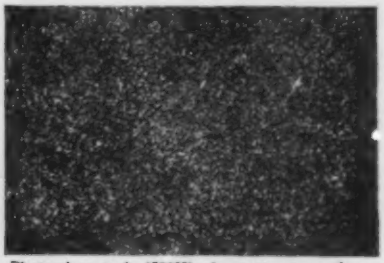

Photomicrograph (500X) shows structure of an AISI 4140 steel bar, hardened and tempered with Selas short-cycle heating. Yield Strength = 140,000 psi; Tensile Strength = 152,000 psi; Hardness = 32 Rc. Compare this with conventional heating methods, which for 152,000 psi T. S. produce only 115,000 psi Y. S., and to achieve the required 140,000 psi Y. S., it is necessary to go to 180,000 psi T. S., with hardnesses that introduce machining problems.

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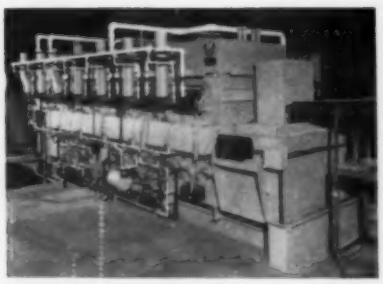

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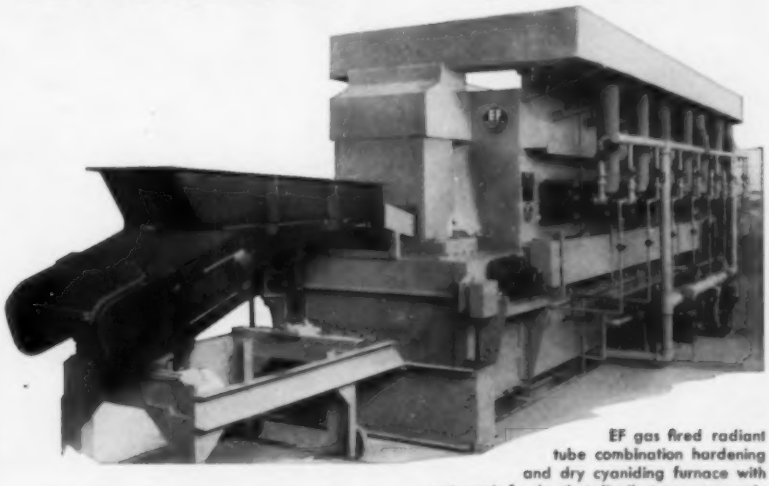

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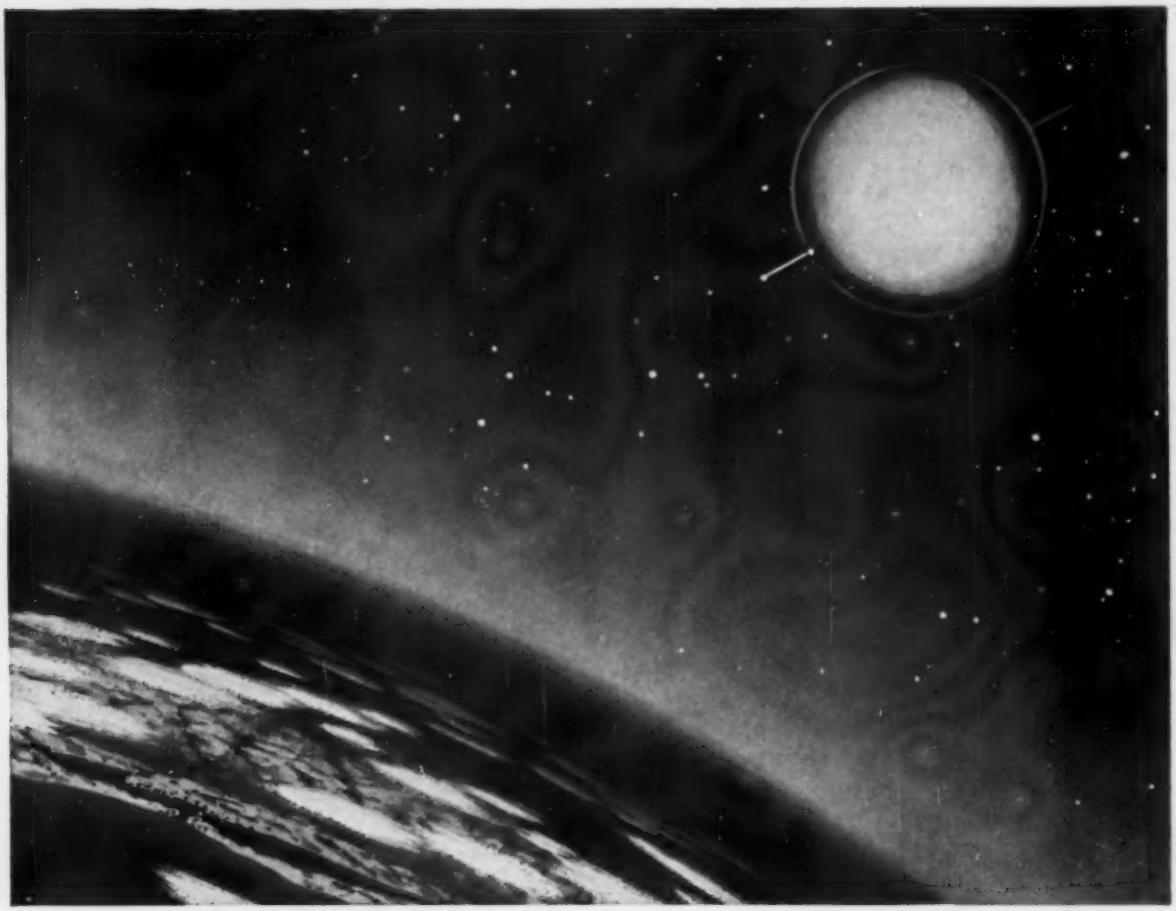

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